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LIGHTNING RODS.

THE utterances of Dr. Oliver J. Lodge, upon the action of lightning, do not appear to have borne fruit, though it is perhaps a little early to expect that anything material should have resulted from his interesting and suggestive researches. In a recent paper read before the American Institute of Electrical Engineers, Mr. N. D. C. Hodges has discussed some possible modifications or methods of protecting buildings from lightning. The writer of the paper seems to agree with Dr. Lodge as to the necessity of not accepting the general reasoning set forth in books or in the report of the Lightning Rod Conference, seeing that rods erected in strict accordance with generally accepted ideas, have failed to answer the required purpose. The result of his researches brings him to the conclusion that a conductor that can be easily dissipated by a lightning discharge, protects the building to which it is attached between two horizontal planes, the one passing through the upper end of the dissipated conductor, and the other at the lower end. A lightning rod, therefore, which weighs but 1 lb. per 75 feet, and made in sections 2 feet long, and which are tacked to the building from its ridge-pole to the foundation, the joints being made of low conductivity by the insertion of insulating washers, will protect the building—at least, so says Mr. Hodges. The conductor becomes destroyed by the discharge. One hardly knows whether to take Mr. Hodges' suggestion for the new form of protector as a serious one or not; the advantage of a protector which becomes destroyed after a flash has struck it is not obvious, for though cheap as regards the weight of the metal it cannot be cheap when the work of fixing it to a building is considered. The inventor states that "so far he has found no case on record where the dissipation of such a conductor has failed to protect the building under the conditions explained." Has he cases on record where the conductor has actually been struck and dissipated, and the building to which it was attached has been saved? It would be interesting to know whether a discussion took place on the paper in question, and what were the opinions expressed on the subject. The whole question of the efficacy of lightning rods is shrouded in difficulties, seeing that the general principles which have been laid down as necessary to be carried out may apparently, but not actually, have been complied with, and consequently damage result, this damage being erroneously ascribed to faulty principles, instead of to a wrong carrying out of those principles. At the same time we hesitate to say that the old principles are undeniably correct, though we have great confidence in them. The *raison d'être* of Mr. Hodges' paper may, however, probably be found in the fact that a new lightning protection company is being promoted in New York.

EMPLOYERS AND INVENTIONS OF THEIR EMPLOYEES.

IT is not an uncommon occurrence, when speaking of some successful invention by which the manufacturers thereof have secured a fortune, to hear it remarked that so and so, one of their employees, was the real inventor, and that his employers sucked his brains for their own benefit, while the man himself who deserved all the credit was left to starve, so far as any personal reward, beyond his pay, had been derived from the exercise of his ingenuity and skill.

In nine cases out of ten this discontent on the part of the workman is not justified, for more often than not it will be found that the so-called inventor has been specially retained for the set purpose of improving some apparatus which is already in existence in a crude form. The idea may be good, but the details, by which the desired object can alone be attained, require working out, so an assistant is appointed to give his whole time to accomplish this, for which he will be paid. As a rule, if his industry leads to success, he will indirectly participate in his master's prosperity by gaining a permanent position on the works.

It is to be regretted that the employers do not more frequently, of their own accord, present a bonus to those who have helped to forward their interests, but the obliga-

tion to do so is simply a moral one, which cannot present a a shadow of right to legal enforcement.

On the other hand a workman, during his own time, making an improvement in an invention, is not debarred from taking out a patent in his own name, the subsequent control of which will rest upon his capacity for commercial negotiation.

A decision by the Supreme Court of the United States of America takes this view of the matter. The suit was brought by one Solomon, assignee of Clark, against the United States, to recover damages for the use of a self-cancelling stamp, invented and patented by Clark. Clark, when in the employment of the Government, was assigned the duty of devising a stamp. The stamp he produced was satisfactory, and was adopted by the Commissioner of Inland Revenue. After this Solomon, as assignee of Clark, was granted a patent for the invention.

The following is an abstract of the judgment of the Court in favour of the Government :—

"The Government has used the invention of Mr. Clark, and has profited by such use. It was an invention of value. The claimant and appellant is the owner of such patent, and has never consented to its use by the Government. From these facts, standing alone, an obligation on the part of the Government to pay naturally arises. The Government has no more power to appropriate a man's property invested in a patent than it has to take his property invested in real estate ; nor does the mere fact that an inventor is, at the time of his invention, in the employ of the Government, transfer to it any title to or interest therein. An employee performing all the duties assigned to him in his department of service, may exercise his inventive faculties in any direction he chooses, with the assurance that whatever invention he may thus conceive and perfect is his individual property. There is no difference between the Government and any other employer in this respect. But this general rule is subject to these limitations :—

"If one is employed to devise or perfect an instrument, or a means for accomplishing a prescribed result, he cannot, after successfully accomplishing the work for which he was employed, plead title thereto as against his employer. That which he has been employed and paid to accomplish becomes, when accomplished, the property of his employer. Whatever rights as an individual he may have had in and to his inventive powers, and that which they are able to accomplish, he has sold in advance to his employer.

"So, also, when one is in the employ of another in a certain line of work, and devises an improved method or instrument for doing that work, and uses the property of his employer and the services of other employees to develop and put in practicable form his invention, and explicitly assents to the use by his employer of such invention, a jury, or a court, trying the facts, is warranted in finding that he has so far recognised the obligations of service flowing from his employment, and the benefits resulting from his use of the property, and the assistance of the co-employees of his employer, as to have given to such employer an irrevocable license to use such invention."

M. DE MERITENS'S BATTERY.

EPILOGUE.

M. DE MERITENS, after much reflection, decided to submit his battery to the *Laboratoire Central d'Electricité*, where it was subjected to experiments, the results of which were communicated to the *Société Internationale des Electriciens* on the 4th inst. We will now give a *résumé* of the results obtained, and the conclusions to be drawn from them.

As might have been expected, the battery sent to the laboratory was not the one submitted to M. Hospitalier, but an element that was widely different as regards both composition and dimensions. In this new element the carbon has completely disappeared, so that it is identical with the element which Baron d'Ebner exhibited in 1867 at the International Electrical Exhibition, and the description of which is to be found in Cazin's and Angot's treatise on batteries. In the second place, the surface of zinc in the element experimented upon was 3·8 square decimetres, whereas that submitted to M. Hospitalier by M. de Méritens had only one square decimetre of surface. Lastly, in order to keep up the strength of the solution of sulphuric acid, M. de Méritens had provided his element with porous tubes filled with sulphuric acid, as in M. Cloris Baudet's battery, although in M. de Méritens's original communication of last February these tubes are not mentioned.

Notwithstanding these altered conditions, and taking into account the differences of output given by M. de Méritens to suit the needs of his case, the results obtained at the laboratory confirm M. Hospitalier's figures, and could not do otherwise than confirm them.

The following table sums up the results of the four experiments ; it has been drawn up by taking on the one hand the figures given by M. de Nerville as the results of his three experiments ; and, on the other, those given by M. Hospitalier as the averages of his personal experiments :—

	Mean of M. Hospitalier's experiments.	Experiments at the Laboratoire Central d'Electricité.		
		1st series.	2nd series.	3rd series.
Total surface of zinc in sq. decimetres	1	3·8	3·8	3·8
Mean output in ampères	5·2	2·93	46·25	10·8
Mean output in watts (per element)	3·2	1·94	8·45	6·35
Mean specific current in ampères per *d/m* of zinc...	5·2	·77	12·4	2·84
Mean specific power in watts per *d/m* of zinc	3·2	·50	2·22	1·67
Initial electromotive force before the output* ...	variable	1·05 & 1·11	1·17 & 1·24	1·48 & 1·57
Electromotive force after output (at breakage) ...	·75	·8	·65	·785
Mean useful difference of potential	·50	·65	·175	·59
Consumption of zinc per kilowatt-hour in grammes	2,460	1,860	6,880	2,150
Consumption of sulphuric acid per kilowatt-hour in grammes ...	6,000	14,000	43,000	12,200

* The figures relate respectively to each of the two elements experimented upon.

The only value that seems to differ much from that given by M. Hospitalier relates to the *initial* electromotive force, but this is easily explained by the fact that M. de Méritens was permitted, for what reason we do not know, to take the zincs away between the series of experiments. The same zincs were not used throughout, for those brought back for the

third experiment were heavier than those used for the second. It is well known that by amalgamating the zinc with mercury containing a metal higher in the electrochemical series than zinc itself, a much higher electromotive force can be obtained. This electromotive force lasts until the auxiliary metal is exhausted; it then falls immediately to its normal value, ·8 of a volt in this particular case.

The first trial at the laboratory was made on a ridiculously small scale, and this is how it was that a mean available difference of potential of ·65 of a volt per element was obtained, instead of ·5 of a volt, as stated by M. Hospitalier. According to the scale of output adopted in this first experiment, more than 500 elements would have been required to produce 1 kilowatt, and the battery would have been of no use for industrial purposes.

In the second experiment the current has been exaggerated in the opposite direction; thus the consumption of zinc has attained the improbable value of 6,880 grammes per kilowatt-hour, instead of 2,460 grammes, as stated by M. Hospitalier, and the mean available difference of potential only ·175 of an effective volt per element, instead of ·5 of a volt. Practically, the results of these experiments should be rejected, as they correspond to conditions of working which are equally ridiculous in one sense or the other.

It is in the third experiment that the results most nearly approach those obtained by M. Hospitalier; but it must be remarked that the specific output of the battery, in watts per square decimetre of surface of zinc, was only 1·67, instead of 3·2. By thus reducing the output by nearly one-half, the available difference of potential is naturally increased; but then we are no longer dealing with an industrial battery of large output.

According to the figures obtained at the laboratory alone, it follows that the consumption of the zinc-platinised lead-diluted sulphuric acid battery consumes from 1,860 to 6,880 grammes of zinc per kilo-watt hour. Thus by giving the value of 2,460 grammes as corresponding to the mean outputs which had previously been indicated by M. de Méritens, M. Hospitalier quoted a value which is really practical, and which is sufficient to show the industrial value of this battery, which presents no more novelty than economical advantages.

And, again, we have not entered into the consumption of sulphuric acid, which is at least double the quantity stated by M. Hospitalier, who supposed the acid to be utilised until it was half exhausted. In order to gain a certain amount of constancy with the help of M. Cloris Baudet's sulphuric acid tubes, we are obliged to leave the liquid of greater strength and to waste it, which brings up the consumption to 12 and even 14 kilogrammes per kilo-watt hour instead of 6 kilogrammes. But what are we to think of the authorities at the Central Laboratory, who having been appointed to decide officially between two members of the Society, conduct the experiments under the exclusive direction of one only of the parties interested, authorise him to take away the zincs, and make experiments with outputs which have no connection with the experiments concerning which the dispute has arisen, and with entirely different elements?

Note on an alternating current motor.

MAURICE HUTIN and Maurice Leblanc contributed a joint paper to the Proceedings of the Academy of Science at Paris, on April 27th, upon a motor which is capable of utilising an alternating current supplied by a single line and in which the couple developed is independent of the speed of rotation. The motor is composed of two rings; the one fixed, the other movable; each ring is covered with two distinct circuits comprising $2n$ coils. The winding is done in such a manner that a current sent into each circuit develops $2n$ poles alternately positive and negative. The two circuits of each ring are disposed symmetrically with regard to each other. The two movable circuits can be closed, each on two resistances, without self-induction and variable at will. The two fixed circuits are mounted with regard to the arrival and departure of the alternating current. The conductors rolled on each have different sections: one is cut by a condenser. This paper is almost entirely taken up with a mathematical discussion of the intensity of current, the electromotive force necessary, and the work done by the machine per second. For this we must refer our readers to the original paper (*vide Comptes Rendus*, Vol. cxii., No. 17, p. 935). An experimental motor has been constructed, and, from the observations made with it, it seems that the theoretical deductions are justified. The motor can be set going with the greatest ease, and when once it is started it works with great regularity. With an alternating current of 75 per second this motor has given about 11 horse-power with a yield of 78 per cent. Alternating currents of great frequency appear to be the most suitable for this motor.

Relative Cost of Cable, Electric and Horse Tramways in the United States.

A REPORT issued by the U.S. Census Department has just been published, and it will be found of interest by electric traction engineers in general. While it is stated that it is too early to form a final judgment regarding the value of electricity for tramway traction, yet the statistics throw considerable light upon the question. The report covers statistics of 50 tram lines, 10 of which are operated by cable, 10 by electricity, and 30 by animal power.

	Cable.	Electric.	Horse.
Total cost of roads and equipment	$26,351,416	$2,426,285	$22,788,277
Cost per mile of road and equipment	$184,275	$36,694	$41,283
Total operating expenses per car mile	14·12 cents.	13·21 cents.	18·16 cents.

As far as the operating expenses per mile are concerned, the cable and electric lines are more economical than those operated by animals. The cable lines, however, were built at a cost of over five times as great as the electric ones; moreover, when cable lines exceed distances of a few miles they cannot compete with electric traction at all; a fact which ought to be distinctly remembered.

Railway Carriage Lighting.

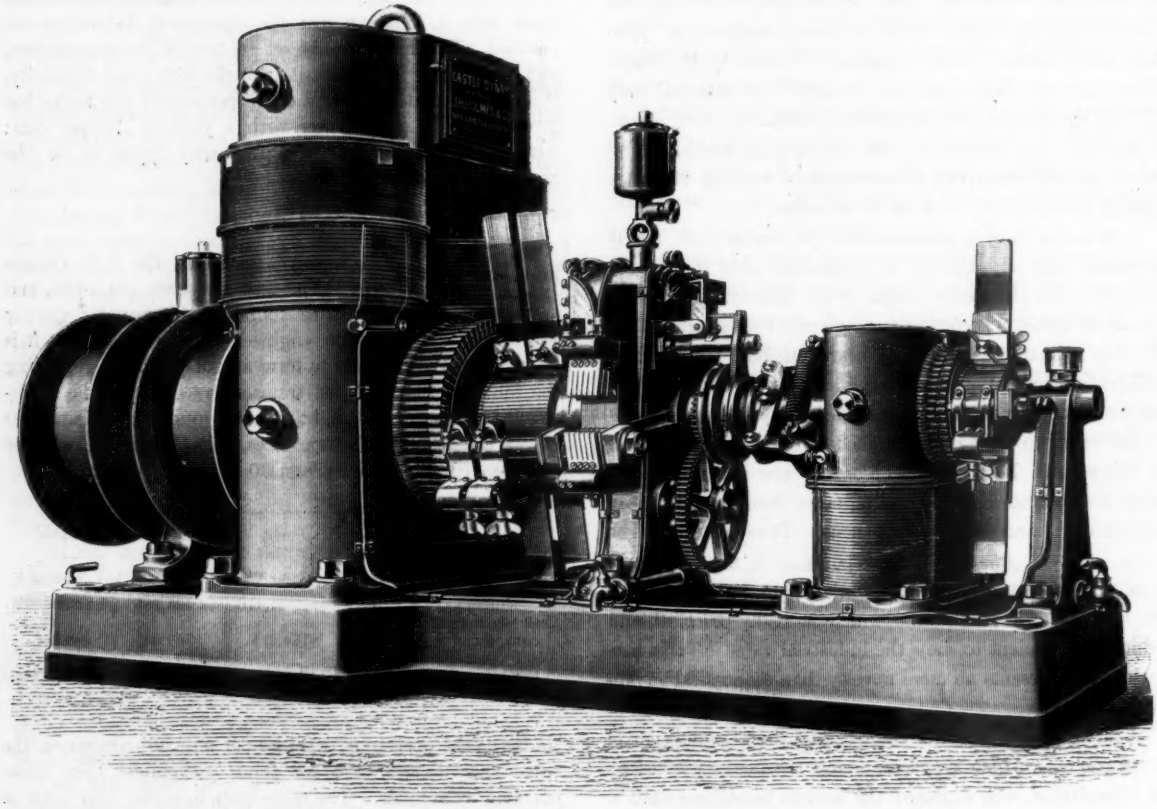
WITH regard to the lighting of railway carriages, it seems probable that the introduction of electric incandescent lamps has stopped, temporarily at least, the progress of gas. Electric lighting ought to go ahead notwithstanding its failures, for the causes are well known and can now be avoided. Electricity is new and at its highest cost, gas is old and its price can scarcely go much lower; the one must come down even if the other does not go up, therefore we hope the Midland Railway Company will see its way to the general introduction on its lines of carriage lighting by electricity. Mr. Langdon has done yeoman service in bringing such an important subject before the notice of the Institution of Civil Engineers.

J. H. HOLMES'S RAILWAY TRAIN LIGHTING DYNAMO.

THE accompanying illustration represents the improved train lighting dynamos manufactured by Messrs. J. H. Holmes and Co., of Newcastle-on-Tyne, and 17, Coleman Street, London, E.C. This apparatus is being employed by the Midland Railway Company, more especially in connection with the electric lighting of their express trains. Mr. William Langdon, of Derby, explained its merits pretty fully in his paper read at the recent meeting of the Institute of Civil Engineers.

It has also been supplied for French, German, and Russian railways.

The apparatus may be briefly described as follows :—This dynamo is the invention of Mr. J. H. Holmes, Assoc. M.Inst.C.E., of Portland Road, Newcastle-on-Tyne, and is constructed with the object of maintaining a constant difference of potential at the terminals of the dynamo under a considerable variation of speed, and when driven in either direction. It depends upon the following principles, namely, practically speaking the E.M.F. of an ordinary separately excited dynamo varies directly as the speed at which the armatures revolves; so, therefore, if the speed be increased, say, from 500 revolutions per minute to 1,000 revolutions per minute, the electromotive force will be doubled. Also the electromotive force varies directly as the strength of the magnetic field, so that if the strength of field of a separately excited dynamo be reduced in the same proportion as the speed at which its armature revolves be increased, then the electromotive force of the armature will remain practically constant.



To this end two dynamos are arranged in near proximity, having their two armatures upon the same shaft so as to revolve together, but influenced by separate magnetic fields. The one is the main generating machine, the other is for regulating the strength of the magnetic field of the generating armature. The magnets of the machines are separately excited from an external source, such as a set of accumulators, and the magnets of the generating armature are provided with two distinct exciting circuits. One circuit is an ordinary high-resistance shunt circuit, and the other is of less resistance, and is coupled up to the source of current, so as to have the small regulating armature in series with it. The regulating armature is so coupled up that its electromotive force opposes the electromotive force of the regulating armature and external source of supply. The high resistance shunt circuit is so proportioned that, at the highest speed at which it is intended to run the generating armature, it, without the aid of the regulating circuit, will give a magnetic field of an intensity proper for the required E.M.F. in the generating armature. When thus driven, the second exciting circuit ought to have no current passing through it, a result which is brought about by the E.M.F. of the regulating armature being at its highest speed, equal and opposite to the external source of E.M.F. produced in the less resistance coil of the generating machine. If, however, the speed falls, the E.M.F. of the regulating armature is lessened in the same proportion, and being no longer equal to the external E.M.F., a current will be permitted to flow through the lesser or second exciting circuit of the magnets of the generating armature, thus increasing the intensity of the magnetic field to make up for reduction of speed, with the result of maintaining a practically uniform E.M.F. in the generating armature.

When the speed falls to the lowest limit, say half the highest rate of speed, the E.M.F. of the regulating armature will be half the E.M.F. of the external source of supply, so that it will be seen that it is necessary to calculate the proportions of the second exciting circuit of the generating armature magnets upon the basis of only half the electric pressure of the external source of E.M.F. being available, and the resistance of the regulating armature forming part of the circuit resistance. At the lowest speed, therefore, half the exciting power upon the generating armature magnets will be produced by one coil having the full difference of potential of the external source of E.M.F at its terminals, and the other half by the second and lesser coil having half that difference of potential at its terminals, less, of course, by the drop of potential due to the resistance of the regulating armature which forms a portion of this circuit.

As arranged for use on a railway train, the armature is driven by belting from the axle of the guard's van, and a set of accumulators furnish the current for exciting the field magnets. A centrifugal governor on the armature spindle automatically switches on the storage batteries for exciting the magnet coils of both the exciting and regulating machine as soon as the speed rises to the minimum speed at which the dynamo is intended to come into action, and it in like manner also switches off the current when the speed falls below the minimum speed, as the dynamo has to produce current when the train is running in either direction; the brushes which collect the current from the two armatures are made of wire gauze, and are placed radial to the commutators, and the "lead" being automatically altered to meet the direction of rotation. The connections to the armatures are at the same time changed, so as to keep the polarity of the dynamo terminals always uniform.

On the spindle carrying the armatures is also arranged a reversing switch, which is actuated by friction discs, which come into friction when the spindle slows down, but which run free on its attaining any degree of speed. The duty of this reversing switch is to insure correct polarity of current.

Working in conjunction with the dynamo is an automatic cut-out such as is generally used in electric light installations, having one—the highest resistance—coil connected to the dynamo terminals, and the other—the low resistance—coil in the main lighting circuit. The duty of this instrument is to cut the lighting circuit at all times except when a current of a sufficient E.M.F. is flowing to meet that arising from the accumulators employed throughout the train.

THE DIELECTRIC CONSTANT OF MICA.

AT the meeting of the Paris Academy of Science, held on April 27th, a note from E. Bouty was presented, in which some work on the dielectric constant of mica was described.

In a previous paper (*Comptes Rendus*, t. cx., p. 1,362) Bouty has shown that the standard mica condenser of Carpentier varied in capacity with the duration of the charge, and that this variation could be observed even when the time was reduced to $\frac{1}{500}$th second. He has also indicated a formula which enables these variations or residues to be calculated by means of two observations.

In his more recent work, Bouty has endeavoured to distinguish the dielectric properties of the plates of mica used. A study of these standards of Carpentier had established that the variation of the capacity between 0·1″ and 1·0″ is generally less than $\frac{1}{2000}$th; it remained to be seen whether within the same limits and with the same degree of approximation, it were possible to discover a dielectric constant for mica: in other words, whether the capacity of the mica plate may be represented by the formula

$$C = \frac{K S}{4 \pi E}$$

where S = the available surface, and E = the thickness of the plates. In the investigation, the value of E was less than 0·01 cm., while that of S was greater than 50 sq. cm.

The measurements were effected by a very simple method, based upon the employment of Lippmann's capillary electrometer, together with an auxiliary microfarad.

Mons. Carpentier supplied silvered mica plates from one of his standard microfarads. These plates were carefully cleaned with nitric acid, washed and freed from every trace of electrolytes by repeated washings and dryings. The edges were then varnished with gum lac and the plates dried at 140° C.

The following values were obtained for the constant K, and in the table the values of S and E are also given.

S.		E.		K.
49·50 sq. cm.	... ...	14·75 μ	... ...	7·91
65·34 „ „	... ...	29·09 „	... ...	8·00
65·11 „ „	... ...	34·88 „		
66·41 „ „	... ...	50·75 „	... ...	7·91
64·15 „ „	... ...	89·00 „	... ...	8·09
			Mean =	7·98

Hence, in a direction normal to the plane of cleavage, mica possesses a dielectric constant which is practically equivalent to the number 8.

When tinned plates of mica were examined, very discordant results were obtained for the value of K; they were much too low. Other irregularities were observed, and these are held to be due to the occurrence of a layer of air between the tin and the mica. If we allow the double layer to have a mean thickness of 5 μ, it is equivalent to a thickness of mica eight times greater, and its pressure will reduce the apparent dielectric constant. This difficulty was overcome by interposing a drop of distilled water or of absolute alcohol between the mica and the tin.

From a number of observations on mica plates in different states, Bouty is led to the belief that the origin of the "residues" observed lies in the electrolysis of traces of foreign matters associated wfth the superficial layers of the mica.

THE ELECTRICAL WORKS OF THE SECTOR OF THE PLACE CLICHY.

(*Continued from page* 296.)

THESE works, the general description of which we commenced in a preceding number and shall shortly complete, were formally opened on April 28th at 9 p.m., in the presence of many eminent scientists, electricians, and politicians. Although they do not yet contain all the machines necessary for the development of the maximum of power, they are quite complete as regards present requirements.

There are three Armington and Sims steam motors turning at the rate of 240 revolutions per minute, and each working two Siemens shunt dynamos connected in series, and giving 200 ampères at a difference of potential of from 450 to 500 volts.

These machines are used when the system is not working at full pressure. The machines for the full service are three Corliss motors of 500 horse-power each, turning at 64 revolutions per minute, and each working a large 8-pole Siemens ring dynamo, with a collector formed of the winding itself.

These 8-pole dynamos are worked directly, and each produce at full load 700 ampères at a difference of potential of from 450 to 500 volts.

The distribution of the available potential of 440 volts is effected by means of feeders; intermediate conductors enable these 440 available volts to be sub-divided at the extremities of the feeders into four parts or bridges of 110 volts each, the difference of potential between each bridge being kept constant by means of regulators and accumulators, as will be seen in the more detailed description which we place before our readers after this note.

Two of the 500 horse-power machines are quite finished, the third will be in a few weeks. The first of these large dynamos has been working for more than three months, the second was started for the first time at the opening of the works by M. Alphand, Director of Public Works for the City of Paris. A nickelled brass plate has been fixed on the machine to commemorate this event, and also the official inauguration. An exhibition of the various paraphernalia of the canalisation, lamps, electric motors, and various applications of electrical energy, showed the spectators, who were not all scientific, the great variety of electrical apparatus, and also the many purposes to which electricity can now be applied.

These works, which are incontestably the finest, and which perhaps, have been established at a greater cost than any others in Paris, do the greatest credit to the *Société Alsacienne de Constructions Mécaniques* of Belfort, who have supplied the whole of the mechanical and electrical apparatus, the system of distribution, the distributing apparatus, and the canalisation, and also to the Joint Stock Company of the Sector of the Place Clichy, directed by M. Lalance. The installation of the entire apparatus has been effected under the direction and superintendence of M. Pirani, to whom we owe the pleasure of having been permitted to inspect the smallest details of the works.

C. G. S.

System of Distribution.—We have already said, in a former article, that the principle of the mode of distribution adopted

for the sector of the Place Clichy consists in maintaining a constant available potential of about 440 volts at the extremities of feeders radiating from the central station, and in coupling, every moment, upon these feeders, a sufficient number of machines to meet the consumption at different times in the day. All the combinations necessary for the attainment of this result are made by means of a general system of distribution established at the works and shown in fig. 1, together with one of the three large dynamos and the steam motor working it. The lower platform is used for the various apparatus for coupling, regulating, and controlling the dynamos, the upper one being devoted to the service of the feeders.

On the lower platform are arranged the commutators, enabling us to introduce between two horizontal bars of copper, between which a constant difference of potential is maintained, the circuits of excitation of each machine and the corresponding rheostats, the armatures of the dynamos, and the current indicators which show at each moment the output of each dynamo, and enable it to be regulated by acting on the excitation. A voltmeter is also placed on each machine, showing at each moment the electromotive force, in order that the coupling on the bars before mentioned may

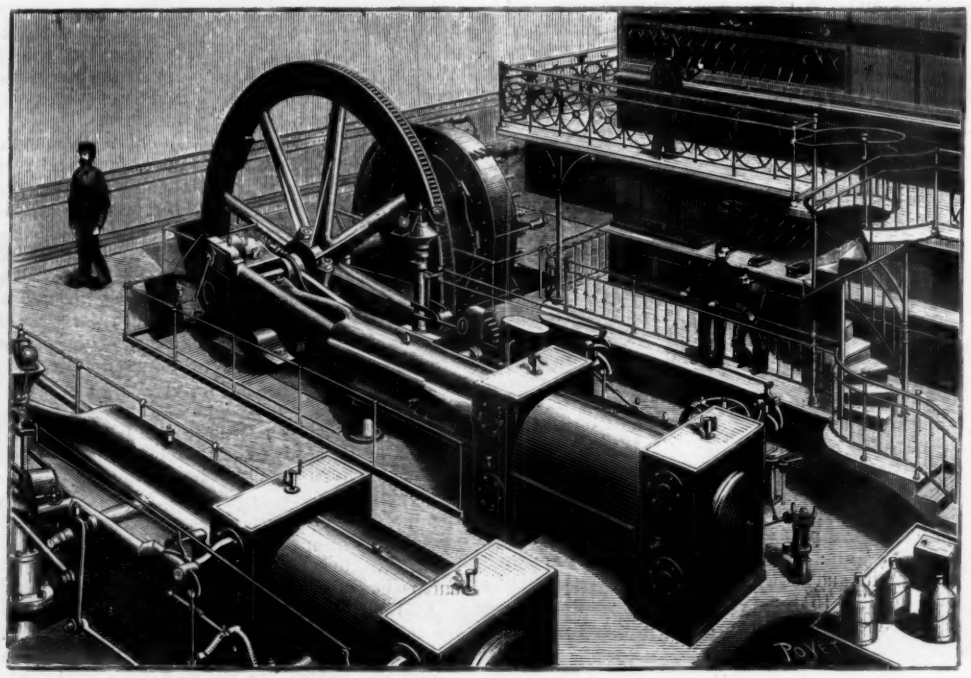


FIG. 1.

be effected at the moment when the electromotive force of the machine is equal to the difference of potential between the two bars. The rheostats of excitation may be manipulated by means of flywheels, either singly or altogether, according to whether it is required to regulate the electromotive force of one machine or that of the entire system.

The feeders, which radiate in all directions from the works, are coupled on the bars on the lower platform. Here, also, end the return wires of each of the feeders, these return wires being connected to voltmeters indicating the difference of potential at the extremities of each of these feeders. The supply through each feeder is as yet somewhat small, the installations of the consumers not being all finished, and there is no great difference between the pressure at the works and the pressure at the end of the feeders. Moreover, up to the present, no special arrangement has been made to effect perfect compensation at each branch. When, in consequence of the increasing number of consumers, the equalisation of the losses on the feeders will be found to be necessary, steps will be taken to ensure this compensation being made as easily and economically as possible.

Distribution.—As we have just said, a series of feeders branch out from the works ending at certain points placed at varying distances from the works, and at the extremities of which is maintained a difference of potential of 440 volts. In order to effect the distribution, it is necessary to divide this difference of potential between four sections or bridges, and to keep up a difference of potential of about 110 volts on each of these bridges, whatever may be the number of utilising apparatus supplied at each moment by each bridge. Two very distinct methods are now being employed at the sector of the Place Clichy to obtain this result: accumulators and regulators.

Accumulators.—In order to divide into four equal portions the available 440 volts, we connect in derivation, at any point of the system of 5 wires, a certain number of accumulators (this number must be a multiple of 4), so that the electromotive force of the battery may be equal to the difference of potential maintained between the conductors.

These accumulators are normally kept charged to saturation. At the sector of the Place Clichy, batteries of accumulators supplied by the *Société Electrique pour le Travail des Métaux*, are employed, to the number of 200 in series for each battery. These 200 accumulators are divided into four groups of 50, and three intermediate conductors are established in derivation on each group, which brings the number of the conductors to five. It is easy to see that, under these conditions, the difference of potential for each of the four bridges will be maintained at about 110 volts.

The accumulators being fully charged, have an electromotive force of about 2·3 volts per element. If all the bridges are equal as to supply, *i.e.*, if they all give out the same current in ampères, the differences of potential for the four bridges are equal by symmetry. If the bridges have unequal supplies, the differences of potential tend to increase where the supply is small, and to diminish where it is large; but compensation is established automatically with inappreciable variations, by the fact that the accumulators connected with the bridges with a large supply are then traversed by a charging current smaller, and the accumulators connected with the bridges with a small supply by a charging current larger than the normal current which keeps the accumulators charged to saturation, when the four bridges have an equal output. For the ordinary service, therefore, the charge of the accumulators will be small or large, according to whether the bridge, with which they are connected, is heavily loaded or not. Thus the accumulators will merely have to compensate for the extreme differences of output of each bridge, and the chief aim of the service of external

canalisation will be to distribute the consumers over the different bridges, so that the variations in the output may be as small as possible, and so that the accumulators charged with effecting the regulation and distribution may not be subjected to very high charges during too long a period, in order that the expenses of installation, &c., may be reduced to a minimum.

Regulators.—The second method employed by the electrical station of the sector of the Place Clichy for dividing the 440 volts over the four bridges, consists in the employment of regulators, one type of which is shown in fig. 2. This regulator, which is an extension of the principle of Elihu

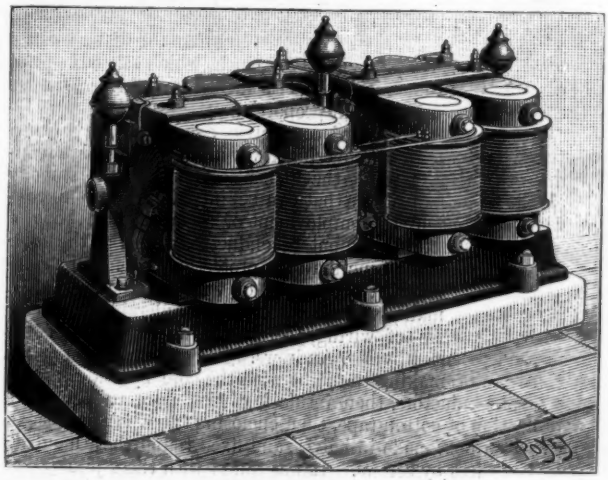


FIG. 2.

Thomson's compensator, is nothing but a quadruple dynamo, with one common axis, the four armatures of which are connected together in series, and in derivation on the 440 volts; three intermediate wires start from the points of junction of the brushes of two successive machines. The armatures of these machines offer a very slight resistance, a condition necessary to the satisfactory working of the apparatus.

If the four bridges are equal, only a very feeble current passes into the armatures, just sufficient to turn the regulator at its normal angular speed and overcome the mechanical friction, which is very slight, the machine turning freely.

If the bridges are unequally loaded, the current is unequally distributed over the four armatures. For the bridges loaded least, the current passing through the corresponding armature is in inverse proportion to that passing through the most highly loaded bridges. As by construction the armatures are mechanically connected, it follows that some act as electrical generators and the others as motors, and thus compensate for the differences of potential which would arise between the bridges in consequence of the inequality in the resistance of the utilising apparatus established on each bridge. The electrical power furnished by the dynamo at 440 volts is about equal to the expenditure of the apparatus and to the sum of the power expended on each bridge; but as these last quantities are not equal to one another, the regulator transfers by means of the common axle the excess of power received by the bridges that have the least load to those that have the most. In short, the accumulators act by variable absorption of energy; the regulators transfer this energy from one bridge to the other.

As equalisers of tension and distributors of energy, each of the arrangements used has special advantges of its own; the regulators take up less space and are less expensive than the accumulators, but the latter have the advantage of constituting a reserve of energy* which is at present sufficient for the night service (from midnight to two or three o'clock in the afternoon), the dynamos being then stopped and the works closed. The comparison which is now being made between the two methods will show us which is the more advantageous from an industrial point of view, and also the conditions that are most favourable to the employment of either system, both, as regards working, giving equally good results.

(To be continued.)

* This reserve of energy is obtained by means of two batteries of 200 elements, the functions of which alternate every day; they act in succession, the one as regulator and the other for the night service, and *vice versa*, the battery discharged to supply the night service being recharged on the following day.

THE QUANTITATIVE EXAMINATION OF REDUCTION PROCESSES BY MEANS OF THE ELECTRIC CURRENT.

A NEW method of investigating reduction processes has been recently worked out by an electro-chemist in Germany, K. Elbs, which is sufficiently interesting to warrant a brief notice. The essential features of this new departure are as follows:—An electric current is passed through a "decomposing" cell, taking on its way an ordinary galvanometer; the cell contains either an acid or an alkaline solution of the substance which is to be reduced.

The anode is separated from the cathode by means of a porous earthenware plate, and a tube is provided which is so arranged that it can collect and retain for future measurement the hydrogen that is evolved during the process. The electrodes recommended are made of platinum foil, and possess 15·6 square centimetres of surface. The current is generated by from two to four ordinary Bunsen's cells. The readings are taken every five minutes throughout the operation, and averaged on one hour.

The amount of hydrogen gas which is used up in reducing the substance that is under examination is given by the difference between the amount actually evolved and the amount which theoretically should be evolved, as calculated from the intensity of the current which is shown by the readings of the galvanometer.

In the original paper, which may be consulted in the *Journal für Analytische Chemie* (series [2], No. xliii., pp. 39—46), Elb gives full details respecting the strength of the solution, the intensity of the current, the hydrogen liberated thereby, the hydrogen evolved, the hydrogen consumed in the reduction, and the temperature observed in each of his experiments.

The substances which were placed under examination by this new method were the following:—

Ortho-nitro-phenol.
Para-nitro-phenol.
Ortho-para-nitro-phenol.
Picric acid.

It is obvious, however, that the method is capable of fairly general application. When a substance is to be examined by this method, it may be dissolved in water or alcohol of different strengths, say to the extent of 0·01 or 0·1 gramme-molecule per litre.

In Elb's experiments, the quantity of sulphuric acid added was generally two gramme-molecules; but in some cases this quantity was raised to four gramme-molecules. In cases where the alkali sodium hydrate is used, it is recommended that a quantity equivalent to two gramme-molecules be added.

When a stronger current is used than that yielded by four Bunsen elements, it does not appear that a proportionately greater reduction is effected, and a less percentage of hydrogen seems to be consumed. Greater reduction occurs in alkaline than in acid solutions.

The author of this interesting method of examining reduction processes has not, unfortunately, classified his results; moreover, on looking at his figures, it becomes evident that nearly every condition varies in every experiment made, and it is difficult to discern what relation, if any, exists between them. It is obvious, therefore, that a more extensive series of experiments, embracing a number of typical reduction processes, ought to be undertaken before any general conclusion can be legitimately arrived at.

O

ANDREWS'S SYSTEM OF CONCENTRIC WIRING.

THE system of concentric wiring we are now about to describe is not only the result of recent thought and experiment, but it has been perfected during several years of gradual development, and the various details and appurtenances have been protected by letters patent. There is also a long list of installations in which it has been installed in its various stages of development. An idea of the general appearance of the wiring is given in fig. 1, from which it will be seen that the

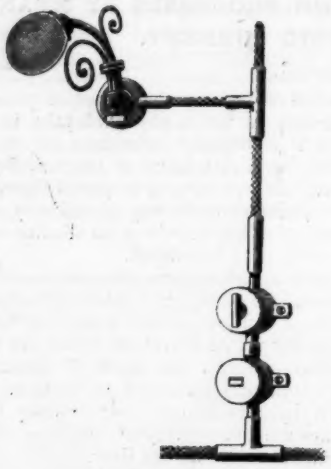


FIG. 1.

system resembles more that of gas than what we are accustomed to in the present electric wiring, and it possesses to a marked degree the substantial and simple character in all details that we find in the gas-pipe system, besides having a completely systematic and interchangeable arrangement of all parts. One of the great advantages gained by the system is safety against fire and interruption. This result is gained by the construction of the wire or cable in which the one wire, say, the lead, is completely surrounded by the other with a waterproof durable insulation between them, and the surrounding conductor is made very heavy as compared with the central for the purpose of supplying ample metal to secure an absolute short circuit in the case of any fault happening which would generate heat and break down the insulation. The choice of the class or construction of the wire was a matter of considerable importance and difficulty, and the forms at present adopted are the result of much experience. Some of the forms that Mr. Andrews tried during the early stages are worth relating. One of these modifications consisted of a copper central conductor with glass beads threaded on to it, and afterwards drawn into a copper or brass tube nearly fitting the beads. We understand this was never practically introduced, and for obvious reasons. Wire with a non-waterproof insulation covered by a lead tube and light iron armouring was practically tried and proved unsuccessful. This failure being partly due to moisture in course of time working in at the exposed ends where the wire joins the fittings, and breaking

FIG. 2

down the insulation. The failure was, however, also due to the lead casing becoming damaged at bends and exposed places. The class of wire most employed is copper, with vulcanised India-rubber insulation, armoured with galvanised iron wires which form the surrounding conductor. The cross-sectional area of the armouring is usually made seven times that of the central conductor, to maintain the same resistance in both. When the cables are larger, the armouring or outer conductor has to be laid on in two layers, as in fig. 2, in order to secure sufficient sectional area without increasing the diameter excessively. The smaller size wires, when they are to be laid on the face of the walls, are reduced in diameter to $\frac{1}{4}$-inch by using copper outer conductors as well as inner, but this is only recommended when the wires are exposed to view. When the wires are to be laid in plaster, they are covered over the outer conductor with a bituminous compound and yarn for protection against possible acids. Beyond this, no protection is used or required. An idea of the exceeding neatness of this mode of wiring may be gathered from the fact that the diameter of a wire to carry five lights is only $\frac{5}{16}$-inch, which takes the place of a wood casing measuring $1\frac{1}{2}$ inches by $\frac{1}{2}$ inch. Larger cables are even smaller in proportion.

Many other forms of concentric conductors have been tried, such as lead covering over a copper outside conductor, with the result that it is also found not to embody all the valuable features that can be introduced into a concentric system by the employment of a considerable body of a tenacious metal as the outer conductor, which, at the same time, performs the function of a protection to the wire.

The jointing of two lengths of wire together, or of a branch to a main, was a matter of considerable difficulty with this class of wiring, before the introduction of the method patented by Mr. Andrews. The early forms of joints consisted of making the joint with the core by soldering the central conductors, then insulating with pure rubber and a protection of cotton tape, then enclosing the whole in a small cast iron box, made in halves, and fixed round the armouring of the wires by screws. It was found with these joints that the current through the outer conductor generated heat at the contacts with the joint box. These defects have been entirely overcome in the new joint, of which fig. 3 represents

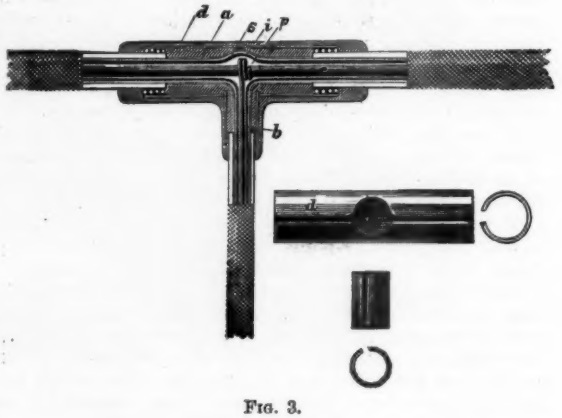


FIG. 3.

a section. After preparing the place for the joint by cutting away the outer conductor, and tapering the insulation from both sides, so as to expose the central conductor, C, the inner conductor of the branch, *b*, previously prepared, is joined on and soldered. The insulation is then lapped on, first, a layer of pure India-rubber, P; secondly, an intermediate layer or separation, I, of India-rubber and soapstone; thirdly, a lapping of India-rubber mixed with sulphur, S. The joint thus prepared is lapped with silesia cloth, *a*, and copper sheaths, *d*, are placed over the spaces cut in the outer conductors. An iron mould is now held round the joint by screws, and a molten metal, fusible at a low temtemperature, is poured in at a suitable gate; the mould when cold is removed. This method of making good the outer conductor is most effectual. The parts of the joint are completely soldered together, and the heat of the metal thoroughly vulcanises the India-rubber of the joint. Joints such as these are not only better than the old cast iron or brass box, but they are also much cheaper. The joints, with the fittings, switches, and fuses, &c., and the wires are made in the same way, such articles being provided with a pro-

jecting tube and wire. The part of a fitting which is connected to the wiring is called a wall socket, and is illustrated in figs. 4 and 5. It consists simply of an angle or knee pro-

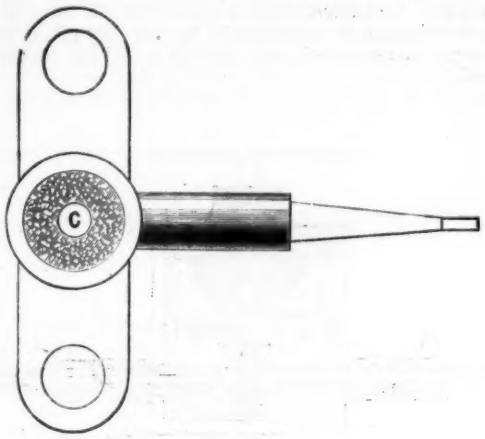


FIG. 4.

vided with lugs for fixing to the wall or ceiling. A central wire, *w*, attached to a contact, C, passes out of the trunnion, T, and cut short ready for jointing to the central wire of the

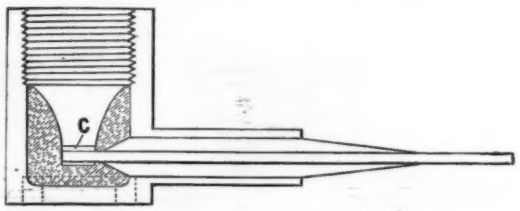


FIG. 5.

leads, as previously described. The contact, C, is held firmly in position by an insulating stone, manufactured for the purpose. This socket may either be fixed to the face of the

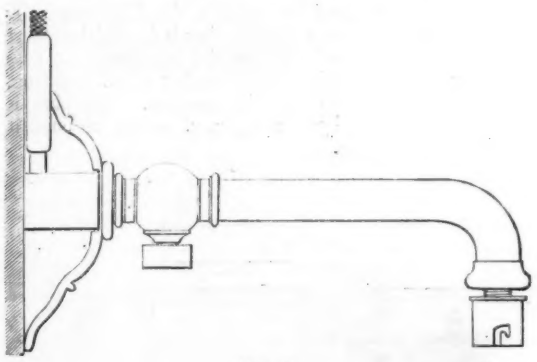


FIG. 6.

wall and covered with a hollow plate, as in fig. 6, or it may be sunk beneath the face of the wall or ceiling with its opening flush with the face, as shown in fig. 7. Fittings intended to screw into this socket are provided with a male screw end and a projecting spring, as shown in fig. 8, which makes contact on the contact, C, of the wall socket. This spring is attached to the central wire of the fitting, which terminates in a recessed contact at the other or lamp end, into which may be screwed the lamp direct or a lampholder. All parts of fittings are constructed with a male and female end, and having started with a fixed female screw in the socket, it is evident that it must always be a recessed end that is left unprotected, thus securing safety against possible short circuits by bridging the contacts at the ends. The insulation of the contacts and springs, and wherever a contact is made, is stone composition of great hardness. The switch used in conjunction with these fittings is shown in section in fig. 8. The central wire of the fitting is opened, and made to terminate in contacts, *a*, *a* ; a brass disc B is placed facing these contacts, and is held from them by a spring, *c*, a cam mechanism, *d*, is provided to move the disc to and from the

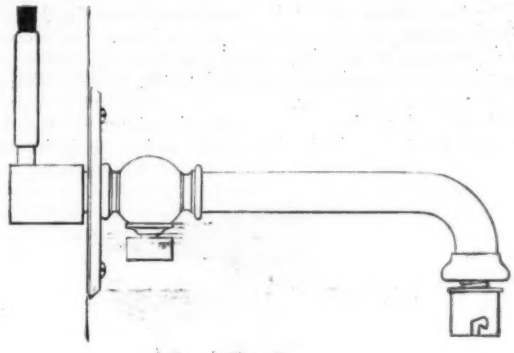


FIG. 7.

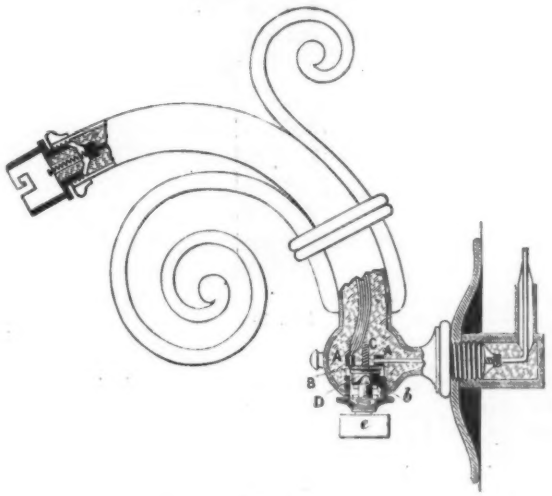


FIG. 8.

contacts by turning the handle, *e* ; on the stem of this handle there is a cross-head pin, which works on the face of the cam, forcing it to or from the contacts according to the direction

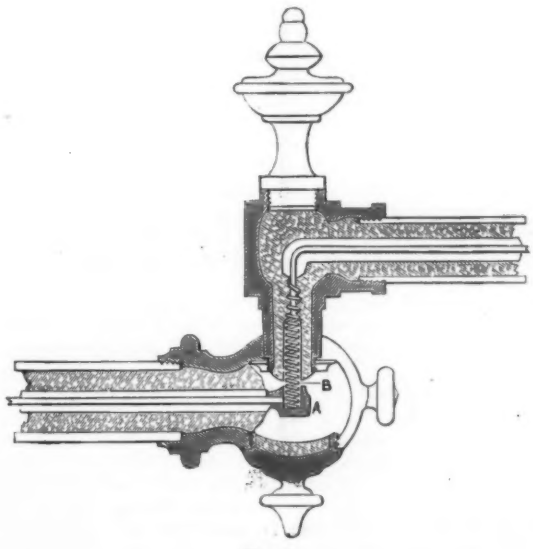


FIG. 9.

of turning. A pin, *f*, in the cam works in a wide slot in the frame, and prevents the cam turning beyond the limits of

the slot; having a certain latitude in the slot, the cam flies back quickly when the handle is turned towards the off position, thus securing a sharp break of the circuit. The insulation of this switch is throughout the same stone composition as is used at the contacts of the fittings.

Thoroughly practical jointed fittings are exceedingly easily made in this system, as will be understood from fig. 9. In outer appearance the joint resembles a gas joint. The central wire of one part of this joint terminates in a cup contact, *a*, in which presses a spring, *b*, attached to the contact wire of the other part of the fitting.

Ball and socket joints are of equal simplicity, as will be seen from fig. 10. A is the usual wall socket, with its recessed contact, B, upon which presses the terminal spring of the central wire. The fitting is hung on a ball joint, C, the centre of oscillation of which is at the contact, B.

FIG. 10

Raising and lowering pendants are constructed with two telescopic tubes, insulated from each other with Andrews's patent stone insulation previously referred to.

Flexible pendants are also used with this concentric system, and the flexible wire being concentric, has an even round appearance. These pendants are usually provided with a union junction to screw into the roof or wall socket, as shown in fig. 11.

FIG. 11

The larger switches for operating a number of lights are of similar construction to the one shown in fig. 8, for a single light; the difference being that the contact disc is made to rotate with the handle spindle, by passing a square prolongation of the latter through a square hole in the disc, *d*, fitted with insulation as shown in fig. 12. By giving rotation to the contact disc in this manner, a rubbing contact is secured.

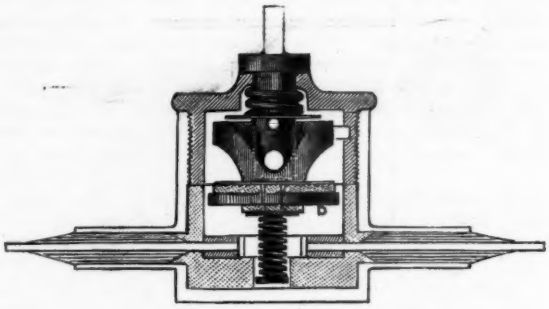


FIG. 12.

The fuse of this system looks like a switch without the handle. It is a brass box, fig. 13, which forms the outer conductor containing a plug, P, upon which is mounted a tin fuse wire, *w*, attached to contacts fitted diametrically opposite. These contacts, when the plug is in position, meet the contacts of the ends of the central conductors that pass out of the box for connecting to the leading wires. A spring, S, in the cover gives pressure at the contacts. The plug is prevented from turning by a fixed pin, *a*, passing through it to one side of the centre.

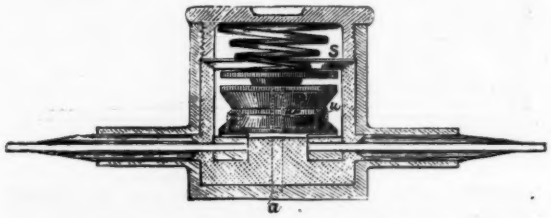


FIG. 13.

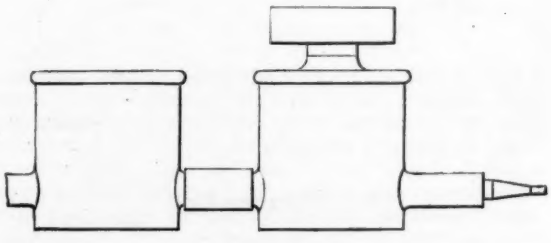


FIG. 14.

Switches and fuses are united together as shown in fig. 14, for the purpose of making a neater arrangement. The method of making this junction is as follows:—The conductors from the contacts of the switch and fuse are tubes concentric with the trunnions of the switch fuse with which they terminate flush. These tubes are connected together by fitting a bundle of hard copper wires tightly into them, and then drawing them together by means of the screw-sleeve on their outer trunnions. This is found to make an excellent connection.

The arrangements of circuits adopted in practice with this system is a facsimile of that employed with gas; the distributing box system now so much the fashion, with double wiring, not being found necessary, on account of the safe nature of the system not requiring the introduction of so many fuses, the usual number of ampères to a fuse is 8, or one fuse to every, say, 12 lights, and with a view to securing absolute safety in the event of a short circuit, the smallest wire used is number 15 S.W.G., it being considered that this size could carry 12 ampères without becoming overheated.

"AUGMENTED" SOLUBILITY OF ELECTROLYTES.

ARGUING from the law of "mass-action" taken in conjunction with the theory of electrolytic dissociation, it has been deduced by Nernst that the solubility of an electrolyte in water should be diminished by the addition to its solution of another electrolyte containing one ion in common with the first. This conclusion has been experimentally verified by Noyes in a considerable number of instances, and we referred to these experiments on page 467 of our issue for April 10th.

It appears, however, that there are several known cases of what may be termed *augmented* solubility that appear to contradict the theory. In the *Zeitschrift für Physikalische Chemie* there is a joint paper by M. le Bon and A. A. Noyes, in which an account is given of the cryoscopic and electrolytic behaviour of some of these apparently exceptional solutions.

For the complete paper, which is a long one, our readers must consult the *Zeit. Physikal. Chem.*, vi., pp. 385—302; we can do no more here than illustrate the results obtained in the investigation.

The solubility of lead nitrate in a solution of potassium nitrate is greater than its solubility in pure water, and the same may be said of potassium nitrate in lead nitrate. These solutions were examined by the well known "freezing-point depression" method, and the results obtained indicate the formation in solution of compound molecules of lead nitrate with potassium nitrate as an explanation of the anomaly.

Strontium nitrate gives results, with the alkaline nitrates, similar to those yielded by lead nitrate, as far as freezing-points are concerned; hence, it might be supposed to be more soluble in potassium nitrate than in water alone, and this was found to be the case.

Other instances of "augmented" solubility were investigated, *e.g.*, mercuric chloride in solutions of hydrogen, sodium, and potassium chloride; silver cyanide in solution of potassium cyanide; iodine in potassium iodide solution, and in all cases in which the anomaly appeared, the results obtained clearly indicated the existence of compound molecules in solution, some idea of the nature of the actual molecules present being obtained.

These results must be held to be confirmatory of Nernst's theory; the general truth of it has already been demonstrated by Noyes in his experiments on the solubility of electrolytically dissociated substances (*vide Zeit. Physikal. Chem.*, vi., 241, and this journal, April 10th, page 467) and now the apparent exceptions to the theory may be regarded as having been satisfactorily explained.

THE CONDUCTIVITY OF ISOMERIC ORGANIC ACIDS AND THEIR SALTS.

THE electric conductivity of free isomeric acids usually vary considerably, but normal salts of acids of simple functions, such as maleates, fumarates, itaconates, mesaconates and citraconates, have the same conductivites. This is true also of all the tartrates, and of the three amidobenzoates, and it is very nearly true for the three hydroxybenzoates.

Mons. D. Berthelot has spent a good deal of time in the investigation of the conductivity of isomeric organic acids and their salts; to him is due some further information recently published on this subject.

Dextrogyrate tartaric acid and racemic acid have identical conductivities, and since the laevogyrate acid is identical with the dextrogyrate acid in all symmetrical properties, this result affords further proof of the dissociation of racemic acid in solution. Mesotartaric acid has a very different conductivity when in the free state.

When an excess of alkali is added to the normal salts, the equality of conductivity persists for acids of simple function, and also for amidobenzoates and the tartrates, a result which indicates that the alcoholic function of the latter is practically inoperative in very dilute solutions. Acids with a phenolic function yield salts with conductivities which are only approximately equal, and they begin to vary still more on addition of excess of alkali, the results showing that ortho-acids yield no more basic salt in dilute solution, whilst the meta and para-acids form polybasic salts.

If increasing quantities of acid are added to a normal salt, the results are different from those with excess of base, but the general phenomena are identical for a large number of acids. With mono-basic acids the liquid behaves simply as a mixture of the normal salt and the acid; with bi-basic and poly-basic acids this does not hold good, in consequence of the existence, in the solution, of partially dissociated acid salts.

Berthelot has observed differences between isomerides, such as fumaric and maleïc acid, mesotartaric acid and the other tartaric acids, on the one hand, and mesoacgnic and fumaric acids, on the other. In the case of the amidobenzoic acids, the basic function seems to be most energetic with the meta-derivative, and weakest with the ortho-derivative.

A REPLY TO TRAUBE'S ATTACK UPON THE HYPOTHESIS OF ELECTROLYTIC DISSOCIATION.

IN our issue for March 27th, p. 389, we gave some account of the rather furious onslaught made by J. Traube on the hypothesis of electrolytic dissociation which has been proposed by S. Arrhenius; we now give our readers an abstract of a reply to the criticisms of Traube, which is published by Arrhenius in a recent number of the *Berichte der deutschen Chemischen Geselschaft* (xxiv., p. 224).

According to the dissociation theory, when a salt is in aqueous solution it is dissociated into its ions, and these are charged positively and negatively with electricity. The ions exist side by side, perfectly free in any homogeneous solution, and owing to their freedom of motion, they so intermingle one with another, that the homogeneity of the solution is never disturbed. If, however, the solution be not homogeneous, and varies as regards degree of concentration, a diffusion of the salt will take place from the region where the solution is more concentrated to the region where it is less concentrated.

Now, since one kind of the ions will move more rapidly than the other, a larger number of these will pass into the less concentrated region than of the other. The result of this movement will be to cause this region of the solution to take the electric charge of these ions, and the other region the charge of those that remain. After a while a certain tension will be established, and a state of equilibrium will result, in which equal diffusion of both ions may be said to take place in unit of time.

Electrolytic dissociation differs from ordinary dissociation therefore—as J. Traube asserts; but in the case of homogeneous solutions, both kinds of dissociation exhibit the same properties.

Arrhenius goes on to say that the hypothesis of electrolytic dissociation does not demand that all properties of dilute solutions shall be of an additive nature. In such cases, however, in which additive properties in solution may be predicted, these have always been found. The specific conductivity and specific resistance of water aptly illustrate this statement. The first should, according to the theory, be proportional to the amount of the dissolved salt, and this is found to be the case; for the second, the hypothesis makes no prediction, and in practice it is not found to be the case.

Traube made a great point about colour. Arrhenius says that the colour of any particular ion in solution should be the same, but in the instances which are quoted by Traube, the ions are in every case different.

Arrhenius denies that the dissociation theory stands altogether in contradiction to the "hydrate" theory, and states that he himself pointed out the possibility of the existence of molecular aggregates in concentrated solutions. The "hydrate" theory, he says, has, however, altogether failed to give any explanation of the properties of dilute solutions to which the dissociation hypothesis has been so successfully applied, and even in other cases there is disagreement between the supporters of the "hydrate" theory themselves. This is illustrated by reference to a paper in the *Zeit. Physikal. Chemie*, vi., 1, by S. U. Pickering.

Arrhenius goes on to say that Ostwald's application of the gaseous laws to electrolytic dissociation has led to the establishment of a formula which has been successfully tested in the case of a large number of acids. True, exceptions have been found to the law which the formula embodies, but, he says, sufficient data do not exist at present to serve for the discussion of these exceptions. The fact that heat is developed in some cases of electrolytic dissociation finds a parallel in the case of the development of heat attending the formation of oxygen (3 molecules) from ozone (2 molecules).

In conclusion Arrhenius, as one might have expected, questions the accuracy of some of Traube's statements, and points out that in calculating the values of i from the freezing point determinations and electrical conductivity, precautions were taken to make the numbers obtained from each strictly comparable.

Meanwhile Traube, having to his own satisfaction completely disposed of the dissociation hypothesis of Arrhenius, has substituted for this another, namely, the "association" hypothesis. This is based, not upon the decomposition of simple molecules, but rather of molecular "aggregates;" for an explanation of which *vide* a paper by Dr. Armstrong in the "Transactions of the Chemical Society" for 1888, page 116.

To bring this hypothesis into accordance with Clausius's theory of electrolytic conduction, Traube considers it sufficient to assume that the double and more complex molecules take no part in conveying the current. He illustrates his "association" theory by the discussion of the behaviour of the double molecule $(K\,Cl)_2$ and adduces the existing evidence in favour of the assumption of complex molecules in pure liquids and in solution. Traube seems also to consider that the validity of Avogadro's law for dilute solutions must still be regarded as an open question.

THE RELATION BETWEEN ELECTRICAL AND CHEMICAL ENERGY IN GALVANIC CELLS.

OF the various transmutations of energy that of *chemical separation* into *electricity in motion* in the voltaic battery, and of the latter into the former in the case of decomposition by a battery, are amongst the most interesting. In the first case, the sources of electrical excitement are the points of contact, say, the zinc and platinum when we have electrical separation produced; but this would not produce a current *per se*, for an electric current implies very considerable energy and must be fed by something. The supply is kept up and really produced by the oxidation and dissolution of the zinc, and the chemical separation of the metallic zinc is transmuted into the energy of the current. In the second case the energy of electricity in motion is transmuted into that of chemical separation when a current of electricity is made to decompose a compound substance; as, for example, when a battery is used to decompose water. Heat apparently disappears during this operation, but it is given back when the mixed gases, oxygen and hydrogen, which result from the decomposition are exploded in a eudiometer.

Recently, this interesting subject has been placed under investigation by E. Lévay; he specially gave his attention to the study of the relation between electrical and chemical energy in galvanic cells, and the object of his experiments was to determine for certain of these cells the heat generated chemically and the heat equivalent of the current, so that he might be able to obtain an exact measure of the difference between the two.

The heat evolved in the cell was determined calorimetrically, and that of the circuit in like manner by means of a silver voltameter placed within the calorimeter along with the cell.

Two cells were examined, namely, the Daniell and the De la Rue, and three calorimetric determinations were made with each cell.

In the case of the Daniell cell, the heat equivalent of the current appears to be greater than that which is generated chemically, so that the net result is that the cell works with an absorption of heat.

The reverse is true in the case of the De la Rue cell; but in this case Lévay observed that the relative amount of electrical energy increases with the concentration of the solution in the cell.

The results show a close agreement with those obtained formerly by Jahn. The original paper appeared in the *Ann. Chem. Phys.* [2], xlvii., 103.

PROCESS FOR SOLDERING GLASS AND PORCELAIN TO METALS.

BY M. CAILLETET.

THIS process is very simple. The part of the glass or the porcelain which has to be soldered is first coated by means of a brush with a slender layer of metallic platinum. For this purpose the objects are slightly heated and coated with a very neutral solution of platinum chloride, mixed with the essential oil of camomile. The articles are gently heated, so as to drive off the essence, and when the white odoriferous vapours have disappeared, the temperature of the object is raised almost to dull redness.

The platinum is thus reduced and covers the article with a metallic coating perfectly adhesive. On fixing the article thus metallised to the negative pole of a battery of suitable intensity in a bath of copper sulphate, there is deposited on the platinum a ring of copper, which must be malleable and quite adhesive if the process has been carefully managed.

In this state, the article thus coppered, may be treated like a real metallic tube, and soldered by means of tin to iron, copper, bronze, platinum, and to all the metals which alloy themselves with tin solder. The solidity and the resistance of thin solder are very great. M. Cailletet shows that a tube of his apparatus for liquifying, the upper end of which was closed by means of a metal piece, thus soldered, resists pressures of more than 300 atmospheres.

In place of platinum, silver may be used, which is deposited by heating glass coated with silver nitrate to near redness. Numerous trials, however, indicate the platinum process as preferable.

THE REFLECTION OF "RAYS" OF ELECTRIC FORCE.

NEARLY a year ago, Dr. Ignatius Klemencic investigated the "Hertz" vibrations by using a thermo-element, which was soldered between the ends of the secondary inductor. Two of these inductors were actually employed: one of them was moved about in the space affected, while the other served as a standard. In this way he found it possible to measure the distribution of energy in a "ray" proceeding from the primary mirror and at right angles to it.

Dr. Klemencic also measured the factor of condensation of a secondary mirror for two different pairs of primary conductors. The value of this factor, in the case of a pair of primary conductors which were made exactly according to Hertz's directions, was found to be 7, but if the length of these conductors was doubled, the value of the factor fell to 2·7. The mirrors used were precisely similar to those employed by Hertz.

In some recent experiments, an account of which appeared

in the *Wiener Berichte* a few weeks ago, Dr. Klemencic has carried his investigation into the reflection of "rays" of electric force a step further. As before, he used two secondary inductors fitted with the interposed thermopile, the one as a standard and the other as a movable one for exploring the affected area; but in these experiments he undertook the examination of the reflection of the "rays" at a dielectric plate of sulphur and at a zinc plate, and to compare also in this respect the behaviour of these rays with those of light.

The sulphur plate was made up of 12 blocks, and it was of dimensions 120 × 80 × 7 cm.; the zinc plate was not so thick. The dimensions of the mirror and plate only allowed of the incident angles 30° to 65° being examined.

There is a difference between reflection at the surfaces of the zinc and sulphur plates which corresponds qualitatively to the behaviour of the rays of light. The intensity of this reflection varies according to the direction of the vibration of the rays. The sulphur plate gives a strong reflection under all angles of incidence if the vibrations are normal to the plane of incidence, but not when the vibrations are parallel to this plane: in this case a faint reflection is found only with small angles of incidence. The intensity of the reflection varies directly with the size of the angle of incidence: at 60°—65° no reflection could be perceived by the methods of observation which were at disposal. This fact agrees fairly well with the optical relation.

With regard to the question of the direction of vibration in polarised light, Dr. Klemencic's conclusions appear to agree with those stated by F. T. Trouton in *Nature* (Feb. 21st, 1889, p. 391), in his paper entitled "A repetition of Hertz's experiments and the determination of the direction of the vibration of light," in which he described an investigation conducted by Professor Fitzgerald and himself.

In addition to this, Dr. Klemencic examined into that portion of the "rays" transmitted by the plates, and he observed that the intensity of the "ray" transmitted by the sulphur plate was the opposite of that of reflection.

THE NEW EDISON DIRECT CONNECTED TRIPLE EXPANSION ENGINE AND GENERATOR.

THE inauguration of the first Edison central station in Pearl Street, New York, in 1882, may be said to have firmly established the system of electrical distribution from a centre, which has now grown to be one of the greatest industries in the world. This station embodied not only many original ideas in the generation and distribution of the electric current, but, in more than one way, embraced principles of mechanical operation which have since been proved by experience to be correct and conducive to the highest economy in operation. Mindful of the fact that every step in the transmission of the power of the engine to the shaft of the dynamo must necessarily involve some loss, Mr. Edison at that early date appreciated the benefits to be derived from the direct connection of the engine to the shaft of the armature. To this must be added the consideration of the space occupied by, and money invested in, countershafting, belting, &c., which in large stations will readily be recognised as involving a large outlay in capital, in addition to the fixed charges required for their maintenance. These considerations, with many others, led Mr. Edison to the construction of his historical "Jumbo" machines driven direct by the Armington and Sims and also the Porter-Allen steam engines. Although these machines might be crude in the light of the present day, the solidity of the design was even then such that not a few of these early machines were until quite recently in successful operation in this city in their original position, and a number of them are still successfully at work in the large Edison station in Milan, Italy. Although this original practice of direct connection was departed from later on, the fact has, within recent years, again forced itself upon engineers that central station practice, in order to obtain the highest commercial efficiency, requires thorough economy in every detail, and especially in the generating plant. Indeed, we may divide every system of distribution under practically four heads; the engine, including the boiler, the dynamo, the conductors; and the lamp or motor. As the efficiency of the lamps, conductors and dynamos, may be said to be a fixed quantity which can be well calculated out beforehand, it is evident that the success of the plant must be largely dependant upon the engine as the prime source of power and the method of its connection with the dynamo. If, with direct connection, therefore, an engine be employed giving the greatest output with the least consumption of fuel under the boiler, the ideal conditions of economical distribution will have been reached.

The recent advances which have been made in engine building, therefore, ought to find one of their principal applications in the generation and distribution of electricity, and it is with this in view, says the New York *Electrical Engineer*, that the Edison General Electric Company have applied the most improved form of engine in a manner calculated, we believe, to have a most marked influence on the future central station practice of this country. Briefly stated, the Edison Company propose to build their compound triple expansion engine not only for generators of the largest type but also for those of the smallest capacity practicable with this type of engine, thus making each type a unit with engine and dynamo directly connected. In employing the direct method of driving, it is evident that the machine must be designed for the speeds practically obtainable under these conditions, and for this purpose evidently the multipolar dynamo is the most suitable. The general design for the larger type of this combination is shown in the accompanying engravings, figs. 2 and 3, which show a front and side elevation of what is known as the 2-75 kilo-watt type, in which two 6-pole generators are employed, attached to either end of the main crank shaft, driven by a three-cylinder triple-expansion condensing engine. Another type of this combination is illustrated in fig. 1, which gives a view of the machine now erected in the central power station at the Schenectady works of the Edison General Electric Company, from which station all the shops included in the works will obtain current for the motors driving the shafting. This combination consists of two dynamos, each of 100-kilo-watt capacity, and the engine capable of working to over 300 H.P. The steam pressure employed is 160 lbs. to the square inch, and the three cylinders have the following diameters:—High pressure, 11¾-inch; intermediate pressure, 17½; low pressure, 28¼ inch. The stroke of the piston is 21 inches, and the engine and armatures make 176 revolutions per minute, giving a piston speed of over 600 feet. Double-ported piston valves are employed, one valve to the high-pressure cylinder, and two each to the intermediate and low-pressure cylinders. The valves are of hard cast iron, turned and ground to fit hard cast iron bushings secured in the valve chest. Crank-shaft governors of special design are employed, and the governors are so arranged that the speed can be adjusted as required. Being designed for central station practice, the lubrication of the engine has been thoroughly worked out, so that the engine is adapted for continuous uninterrupted running.

We come now to the generators. In this type, it will be noted, the armature rotates within a field magnet having 10 poles. The frame of the field magnet consists of but a single casting, and a very ingenious method has been designed by Mr. Edison for winding on the magnetising coils. The Gramme ring type of winding is employed, but instead of using coils of a number of convolutions connected to each segment of the commutator, in this type of machine each convolution is connected directly with the commutator bar. For this purpose bare copper strips of U-shape are slipped over one side of the core, insulated from one another, and each succeeding U-shaped bar of this character is connected direct by a commutator bar. The brushes, it will be noted, bear upon the commutator in a vertical plane. This construction with bare conductors is permissible on account of the very small difference of potential, 1¼ volt, existing between each bar. The number of bars employed in this type of machine is 944, and hence an equal number of commutator bars is employed. Each bar is therefore equivalent to a coil of the usual type of Gramme winding, but the absence of contiguous layers entirely avoids self-induction and hence sparking, the machine operating without the slightest indication of such a disturbance. Eight brushes are employed, which can be shifted simultaneously by means of the hand-wheel shown, and which can also be lifted at once from the surface of the commutator. The resistance of the armature is ·006 ohm, and that of the field

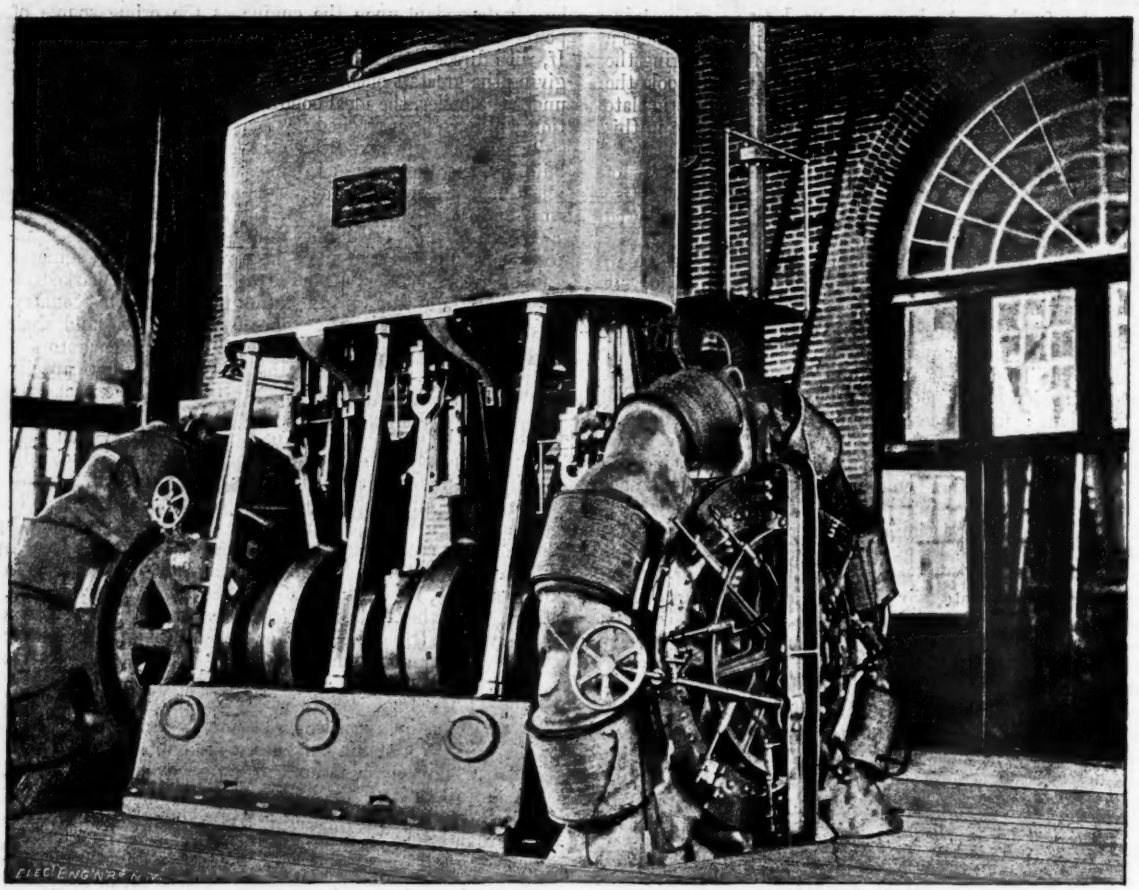
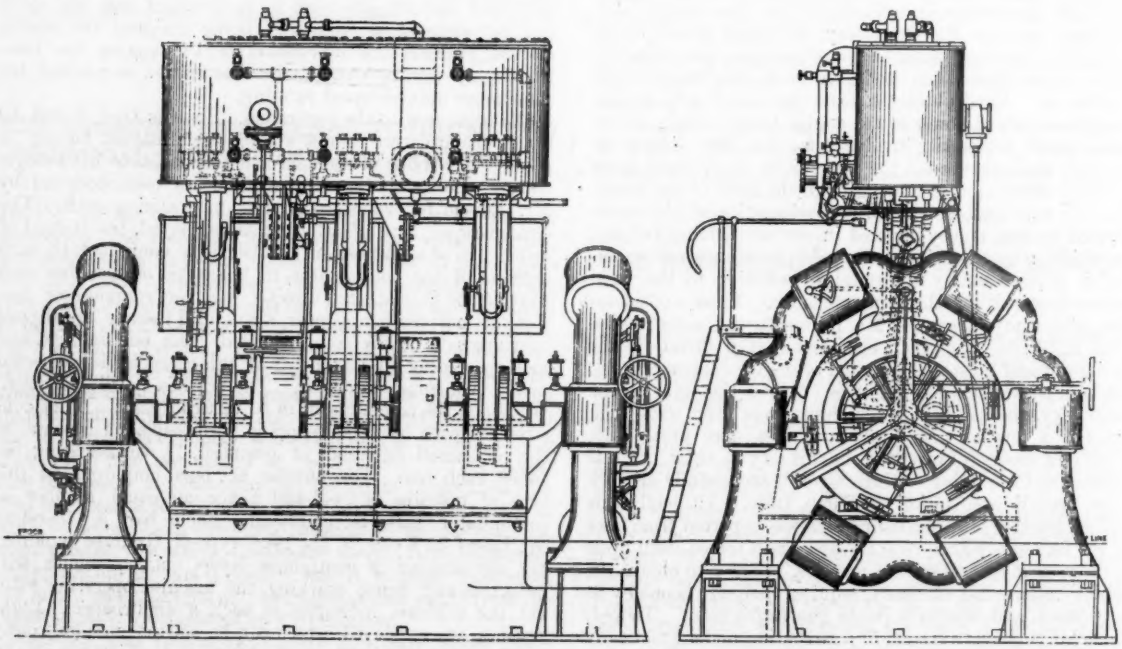


FIG. 1.—COMBINATION OF EDISON GENERAL ELECTRIC CO.'S NEW TRIPLE EXPANSION VERTICAL ENGINE AND NEW EDISON MULTIPOLAR GENERATORS; OVER 300 H.P. CAPACITY.



FIGS. 2 AND 3.—FRONT AND SIDE ELEVATION OF THE NEW VERTICAL TRIPLE EXPANSION ENGINE AND NEW MULTIPOLAR DYNAMO, BUILT BY THE EDISON GENERAL ELECTRIC CO.

8·45. Each dynamo is designed for 150 volts pressure and a capacity of 666 ampères. The design has been so well worked out that a variation of $\frac{3}{4}$ of a load can be made without requiring the slightest change in the position of the brushes.

As stated above, besides the machines already constructed, it is proposed to extend this type over the entire range of available sizes; thus designs are already completed for combination of 2-25, 2-50, 2-75, 2-100, 2-150, 2-200, and 2-400 kilo-watts, in all of which the triple expansion type of engine will be employed. This type of combined engine and dynamo will probably be employed in the new Edison station in New York, where no less than fourteen 2-400 kilo-watt generators will be placed. In the same way the Cincinnati station will be equipped with ten 2-400 kilo-watt generators. The station about to be erected in Milwaukee for lighting and electric railway purposes will contain five 2 × 200, five 2 × 50, and twelve 2 × 100 kilo-watt generators. At Easton, Pa., three 2-100 kilo-watt generators will be erected. In the power station at the Schenectady works of the Edison Company, above mentioned, there will eventually be erected two 2-50, two 2-100, and two 2-200 kilo-watt generators. The new Edison building in this city will also have two 2-25 generators of this type. It is not difficult to foresee the effect which the adoption of high economy generating apparatus of this type will have on the future operation of central stations. It has long been recognised that greater economy is desirable in station operation, and we believe that the methods above pointed out will place the central station operator at once in a position to obtain the maximum output of current with the least consumption of coal.

THE ROYAL SOCIETY CONVERSAZIONE.

IN our note last week, announcing that the first *soirée* of the season had taken place, under the presidency of Sir William Thomson, and that the exhibits were of unusual interest, we expressed a hope we might be able to give some fuller particulars in the next issue of this journal.

One of the most interesting exhibits on view was not in the official programme for the evening, but was introduced by one of the visitors, a friend of Prof. March, of Prague, in Bohemia. It consisted of a series of photographs, showing the discharge of a cannon and the flight of the projectile. There was no information as to the manner in which the photographs were produced, but the appearance of the disturbance of the air and what perhaps may be likened to the striæ effects in a vacuum tube were well developed on the plates. The plates were very small but perfectly distinct in the details. The following sketch will give some idea of the

character of the pictures. The dark part to the left is the muzzle of the gun; the black piece to the right from which the markings diverge represents the projectile.

While speaking of photographs, a series of photographs by Colonel Waterhouse are worthy of mention, illustrating the application of the tetrathiocarbamid-ammonium bromide $(N_5H_2CS)_4NBr$, to the reversal of the photographic image on gelatino-bromide films. Two plates similarly exposed were developed; the first, with "eikonogen" only, was a negative; the other, with the same developer, to which less than $\frac{1}{100}$th of a grain to the ounce was added of the above bromide, was a positive. There was also shown six photos of a lady's head, where the reversal was interrupted at various stages, so that the transition from a negative to a positive could be traced.

The new Wimshurst electrical influence machine (alternating) we recently described, but the one exhibited at Burlington House, the essential parts of which consisted of one rotating disc and four inductor plates, each having its own brush, could be converted into a machine capable of supplying a large and constant electric flow. This was done by dispensing with two of the arms of the inductor plates, and substituting in their place an insulating arm having brushes at each of its ends and a metallic circuit from brush to brush through the terminals.

An apparatus employed by Prof. Roberts-Austen in a research undertaken for the Institution of Mechanical Engineers, and relating to the rate of heating and cooling masses of metal, was shown by the inventor. It consists of a pair of platinum and platinum-rhodium wires, forming a thermo-electric couple. One junction of the wires is inserted in the mass of metal, and the other in a vessel of liquid of known temperature. The electric current passes through a mirror galvanometer, which projects the image of a flame through a fine slot on to a travelling band of photographic paper. There is thus produced on the paper a line, more or less irregular, and by measuring the distance between the line and a datum line formed by a fixed light, it is possible to measure the rate at which the metal under observation absorbs or parts with heat. The instrument is designed for a range of temperature between 600° C. and 1,200° C.

MM. Richard Frères presented for inspection several self-recording instruments, and among them was a very sensitive statoscope for recording atmospheric pressure, consisting of an aneroid connected by a system of levers to an indicator moving over a card and drum, and reading to a variation of pressure of $\frac{1}{10}$ mm.

Prof. Oliver Lodge showed a rotating mirror driven at a high speed, and designed for analysing the electric spark, and for observing the speed of electric pulses along conductors of various kinds. He had also a pair of resonant Leyden jar circuits. One circuit was fed from a Wimshurst machine, and when sparking took place a similar effect was produced in the other circuit, which was several feet away, and quite isolated from the first circuit. The self-induction or capacity of the second circuit could be varied by a slide moving along a part of it where the wires were parallel, and it was shown that a very small change threw the two circuits out of balance, so that the oscillations of the second no longer synchronised with those of the first, and therefore did not grow to sufficient amplitude to overflow in the form of a spark.

Prof. Unwin exhibited a length-measuring instrument which, unlike the ordinary screw micrometer, does not depend on feeling and personal skill, but works with a fixed pressure, while the adjustment of the machine is shown by means of spirit levels.

An instrument called a "focometer" was shown by Prof. Silvanus P. Thompson. It is designed to effect the determination of the two principal "focal planes," and of the two "principal planes of Gauss," for any compound system of lenses, such as a microscopic objective and the lens of a photographic camera. By these measurements there can be determined the true focal length and the position and distance apart of the two vertical optical centres of the lens system. The lens is mounted on a stand and a parallel beam of light is sent through it (say) from left to right. A small screen is moved up until the ray is focussed upon it, and the screen holder is clamped there, the screen itself being temporarily turned aside. Next a beam is sent through the lens from right to left, and the focus similarly found on that side. The first screen is then replaced, and both screens are drawn back from the lens at equal speeds, until the image of each screen is focussed on the other. The displacement given to the screens, which is effected by a right and left handed screw, is equal to the true focal length.

The Tomlinson regulator was shown under the auspices of Messrs. J. E. H. Gordon and Co., and it was designed to obviate the loss of efficiency in tranformers when not working at their full load, so that by means of the apparatus transformers can be put in or out by a current sent from the central station.

Mr. Shelford Bidwell exhibited his selenium lamp-lighter, which lights an incandescent lamp when darkness comes on. In another piece of mechanism he utilises the action of light on selenium for calling attention to the accidental extinction of a ship's or signal light.

Mr. W. Crookes showed his apparatus illustrating his address at the Institution of Electrical Engineers, and it was interesting to find that the country of origin of a diamond could be demonstrated by subjecting it to the molecular stream which causes phosphorescence, and the colour denotes from whence the stone came. Blue being the usual colour for Cape diamonds, red, &c., for Brazilian stones, and for Australian, yellow, blue and green.

Monsieur G. Lippmann sent some photographs of the spectrum, in which, while the films remain colourless in their substance, interference phenomena has produced colour by the direct action of light, and the colour is due to the structure imparted to the film by the stationary waves of incident light during the exposure of the plate. The tints are, of course, permanent, for the same reason as the iridescence of mother-of-pearl is.

The more insight we obtain into the civilisation of the Romans, the more we find their methods of doing work or construction assimilate to the practice of the present time. It is generally understood now that iron played a more important part in their manufactures, and was put to larger uses than has until recently been imagined. Iron girders for roofing purposes were not beyond the skill of their smiths, and if some evidence should be forthcoming as to the process of their production, we should doubtless be right in the conjecture that the Romans employed rolling mills after the modern fashion. A collection of tools and utensils has been found in a pit on the site of the Roman city of Silchester, in Hampshire, which tends to corroborate the above remarks. The articles found are about sixty in number, and include an anvil, a pair of smith's tongs, carpenters' tools, adzes and axes, shoemakers' anvils, plough coulters, a standing lamp, a portable gridiron or cooking stove, a bronze scale beam, &c. The remarkable feature of the exhibit was the close resemblance of some of the tools to those of American make. The axes in form bore a strong likeness to the North American Indian's tomahawk. Again, a plane approaches so near to the Yankee pattern that it is hard to believe it can have proceeded from an ancient workshop; it is entirely of metal, and has a knob at each end for convenience in holding; the only essential difference between the ancient and the modern plane is that the older pattern has the iron placed in a more upright position. This is the only Roman plane yet discovered in Great Britain, or, as far as our knowledge goes, anywhere else. The world evidently repeats itself, or can there be any truth in the traditions which hold that the aboriginal Americans are descendants of refugees from European and Asiatic empires, knowing, as we do, on the veracious testimony of one of their historians, that all our modern inventions in electricity, &c., were used by the inhabitants of North America, not 100 years after the Romans left England for good.

If the collection of exhibits at the Royal Society's *soiree* did not bring forth any startling invention or phenomena, taken as a whole, it was of all-round interest.

MANGANESE IN CELLS OF THE LECLANCHE TYPE.

By EUGENE OBACH.

As a contribution to the question so frequently asked, and also recently referred to in the columns of this Journal (*vide* the ELECTRICAL REVIEW of April 3rd, p. 428), viz., to what extent the manganese, in cells of the Leclanché type, really behaves as a chemical depolarising agent, a few experiments, bearing upon the subject, made about a year ago, may perhaps be of interest.

From two different brands of manganese peroxide (pyrolusite), having prices almost in the proportion of 1 : 2, representative samples were taken and analysed. It was found that No. I. contained 16·09 per cent. of available oxygen, corresponding to 87·5 per cent. of manganese peroxide, and No. II. 15·55 per cent. available oxygen, or 84·6 per cent. peroxide. Three medium size Leclanché cells of ordinary construction were filled with each of the two brands of manganese, mixed with a suitable quantity of crushed retort carbon. After charging the cells with the usual ammonium-chloride solution each one was closed through a resistance of 100 ohms, and its E.M.F. and internal resistance measured from time to time. The tests showed that the three cells of each set were practically alike, and also that there was scarcely any difference between the two kinds of manganese. The subjoined curve roughly shows the fall of E.M.F. with the time for the two kinds of cells, the crosses referring to those containing manganese No. I., and the circles to those containing No. II., each point being the mean of the three cells.

After the lapse of 63 days, when the E.M.F. had fallen to about 1 volt, the circuit was interrupted and the cells allowed to remain open for a month.

During the time of rest the E.M.F. recovered fully 25 per cent., but on again closing the circuit it rapidly fell to the former value within a few days, and continued to fall at about the same rate as before the interruption, as will be seen from the curve.

The experiment lasted altogether 104 days; after this time the E.M.F. had fallen to about half the original value. One cell of each set was now singled out, and the contents of the porous pot weighed and examined, care having previously been taken to thoroughly wash and dry the materials. From the data thus obtained it was possible to calculate the amount of oxygen given up by the manganese peroxide, and since the total output of the cell was also known, and therefore the amount of oxygen corresponding to it, it was easy to deduce the ratio between the total amount of oxygen consumed by the cell and that portion which was derived from the manganese. It was found that No. I. cell contained 304 grammes of manganese and 123 grammes of carbon, No. II. cell 138 grammes of manganese and 132 grammes of carbon. The

analysis of the manganese from the spent cells gave 14·83 per cent. of available oxygen for No. I., and 13·18 per cent. for No. II., corresponding to 80·6 per cent. and 71·6 per cent. peroxide respectively. The oxygen derived from the manganese in cell No. 1 was, therefore, 4·57 grammes, and from No. II. 3·87 grammes, whereas the oxygen required for the electrical output was 7·98 and 8·02 grammes respectively, *i.e.*, about double the amount yielded by the manganese.

It was thought possible that the manganese peroxide in direct contact with the carbon electrode might, perhaps, have lost more oxygen than the remoter parts of the material, and consequently it was separately analysed, the result being that in No. I. cell this manganese contained 15·25 per cent. available oxygen, and in No. II. cell 13·70 per cent., which therefore clearly disproves any such supposition.

As shown, the oxygen derived from the manganese amounts to only half that consumed by the cell, and the other half must therefore have been supplied from some other source. It can hardly be doubted that this source is the atmospheric air, occluded in the pieces of carbon and manganese, and dissolved in the surrounding liquid. It seems very probable that the rapid fall of E.M.F., observed during the first few days after closing the circuit, is due to the disappearance of the greater part of this oxygen. During the period of rest the loss of dissolved and occluded oxygen is partly recovered; but as the curve shows, even the period of a month cannot completely restore the original E.M.F.

The ratio, in which the oxygen is supplied to the cell by the manganese and the air, and which, in the present case, is about equal, probably depends entirely on the rate of discharge, the size of the cell, and the facility with which the air has access to the interior. With a very low rate of discharge and ready access of air, or with frequent intervals of rest, it seems quite possible that very little oxygen is abstracted from the manganese, but mostly from the air, and in this instance carbon alone may suffice for some practical purposes; however, our experiments have shown us that the E.M.F. of such cells, *i.e.*, without manganese, is notably lower from the beginning than that of a good Leclanché cell.

A number of interesting questions in connection with the action of the manganese as a depolariser still remain unanswered, and require further experimental investigation.

ECONOMY IN THE USE OF INCANDESCENT LAMPS.

The calculations of the relative economy of different lamps, given in the article which was published in the Review of last week, were based on data obtained from lamps of American make; as the writer was not aware of any data having been published for English-made lamps at different initial efficiencies. A test on an Edison-Swan 16 candle-power lamp at the marked voltage was, however, published in the Review of January 30th; and, for the purpose of comparison, the following tables have been prepared showing the number of candle-power hours per penny for different hours of burning of the American and English lamps, all calculated for the same initial candle-power, with energy at 8 pence per unit, and the lamp costing 45 pence.

Table Showing the Candle-Power Hours per Penny for Various Lamps having an Initial Candle-Power of 19·3.

When lamps renewed after	Edison-Swan $\frac{W}{CP}=3{\cdot}34$	American $\frac{W}{CP}=3$	American $\frac{W}{CP}=3{\cdot}65$	American $\frac{W}{CP}=4{\cdot}05$	American $\frac{W}{CP}=4{\cdot}55$
100 hours	19·64	19·09	18·14	17·37	17·01
200 „	24·87	22·95	22·08	21·33	20·84
300 „	26·72	23·75	23·06	22·67	22·24
400 „	27·43	23·92	23·35	23·13	22·86
500 „	27·77	23·73	23·42	23·31	23·19
600 „	27·89	23·63	23·30	23·32	23·30
700 „	27·96	23·43	23·18	23·25	23·28
800 „	27·90	23·23	22·95	23·11	23·26
900 „	27·74	23·07	22·76	22·95	23·18
1,000 „	27·49	...	...	...	...

Table Showing the Candle-Power Hours per Penny for Various Lamps having an Initial Candle-Power of 9·6.

When lamps renewed after.	Edison Swan $\frac{W}{CP}=3{\cdot}34$	American $\frac{W}{CP}=3$	American $\frac{W}{CP}=3{\cdot}65$	American $\frac{W}{CP}=4{\cdot}05$	American $\frac{W}{CP}=4{\cdot}55$
100 hours	13·42	12·82	12·59	12·32	12·29
200 „	19·10	17·34	17·21	16·97	16·86
300 „	21·81	19·09	19·08	19·04	19·00
400 „	23·26	19·97	20·03	20·09	20·16
500 „	24·17	20·35	20·59	20·72	20·88
600 „	24·74	20·66	20·86	21·07	21·30
700 „	25·15	20·80	21·03	21·27	21·52
800 „	25·38	20·87	21·05	21·35	21·65
900 „	25·46	20·84	21·05	21·36	21·77
1,000 „	25·41	...	...	...	...

From these two tables it will be seen that the figures for the Edison-Swan lamp are better all through than those given for the American lamps; and this is due to the fact that the falling off in illuminating power of the former is much more gradual, more especially in the first two or three hundred hours, than that shown by the American lamps whose initial efficiency is below 4 watts per candle. In neither case, however, is the economical life of the Edison-Swan lamp as long as 1,000 hours, the 16 candle-power lamp giving the best results when renewed after 700 hours, and the 8 candle lamp when renewed after 900 hours.

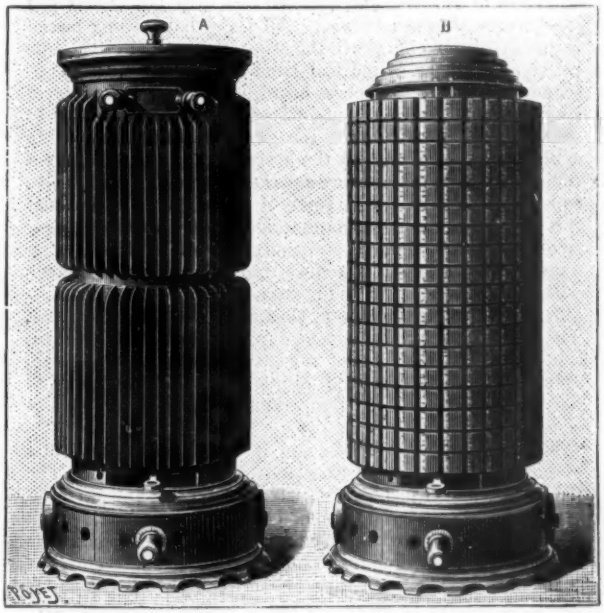
These tables also show clearly the effect of a change in the cost of the lamp or in the cost of power; since the table for the 16 C.P. lamps gives the figures also for the 8 candle lamps when the lamp costs half as much, say, 22½ pence; and the figures for the 8 candle-power lamps, when multiplied by two, give the candle-power hours per penny for the 16 candle-lamp, if the cost of power is 4d. per unit. With cheap lamps or dear power the economical life is shortened, and the higher efficiency lamps are more economical; but with dearer lamps or cheap power, the economical life is lengthened, and the lower efficiency lamps are the cheapest to use.

It would be interesting to see the figures for Edison-Swan lamps when burned at voltages which would give initial efficiencies of, say, 3, 3½, and 4 watts per candle-power; as, if they follow the same lines as the American lamps, it may pay to run the 8 candle-power lamp, so much used now, at a lower efficiency, with the additional advantage that the variation of the lighting power of the lamps when new and old will not be so great as it is at present.

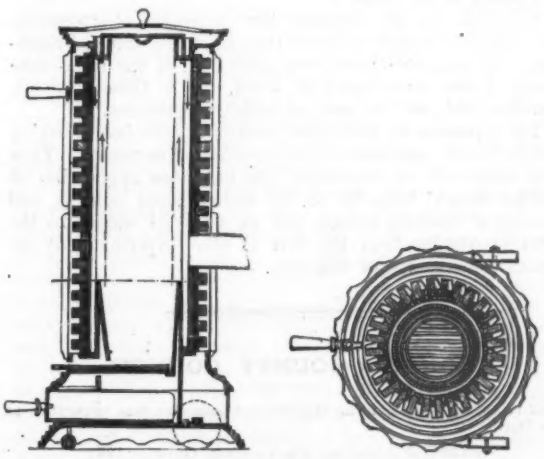
It may be well to add, in conclusion, that in last week's diagrams showing curves of efficiency and candle-power, the words "percentage of initial candle-power" were printed with the curves of watts per candle, and the words "watts per candle" with the curves of illumination.

DR. GIRAUD'S THERMO-ELECTRIC STOVE.

As a sequel to the short leading article which we published in our last number on the future applications of thermo-electric batteries, we will now describe the apparatus to which we alluded in that note, and which is shown in the accompanying figures. This stove does not differ essentially in its outward appearance from the coke or anthracite heating stoves so frequently used in France. We find in this stove that the fuel is supplied through the upper part, that the apparatus is mounted on castors in order to facilitate its being moved, and that the combustion is regulated through the opening, which is more or less large, in the ash pan. The hot gases



A, model in receptacle. B, model with bare elements.



Sectional plan and elevation.

produced by the combustion circulate in two circular receptacles of sheet iron before escaping into the chimney. The thermo-electric elements are placed round the second receptacle. In the model which is now finished, and which we have seen working, the elements are about 700 in number, and are arranged in 25 horizontal circles which occupy the whole of the circumference throughout the entire height of the stove, except at the part reserved for the passage of the pipe conveying the products of the combustion into the chimney. Each of these elements consists of a plate of nickel or tin (fer-blanc), and an alloy with a base of antimony and zinc, with the addition of other metals in very small quantities, the object of which is to impart to the alloy the solidity, mechanical resistance and duration which have hitherto been wanting in the majority of thermo-electric elements. The chief merits of M. Giraud's researches lie in his study of the best proportions to be observed in this alloy, his rapid and economical casting processes, and the arrangement of the elements round the stove.

In order to insulate the elements from one another and to prevent their coming into contact with the hotter parts of the stove, which might cause them to melt, or, at all events, to rapidly deteriorate, the hot part of each element is wrapped in a sheet of asbestos, and enclosed in a little box of stamped sheet iron with a square base. All these boxes being placed in juxtaposition one above the other, the bottom of the side being against the cylindrical front of the stove, they constitute a sort of hollow chess-board, in the compartments of which are the 700 elements, all of which are connected in series. The circulation of the gases is arranged so as to avoid the overheating of the lower circles and yet ensure a sufficiently high temperature for the upper ones, in order to equalise the electromotive force of the elements. Without this precaution some elements would be heated to an excessive and even dangerous temperature, whereas others, being scarcely warm, would introduce into the circuit a resistance which would absorb, on the passage of the normal current, a difference of potential greater than their electromotive force. The continuity of the envelope formed by the little sheet iron boxes, and the mass of the envelopes themselves, ensure an equalisation of temperature practically sufficient to avoid too great differences of temperatures between the various elements.

M. Giraud has two stoves now in action, one with plates of nickel and the other with plates of tin (fer-blanc). The stove with nickel plates gives, when working at full pressure, consuming 28 kilogrammes of coke a day, 40 volts, and 4 ampères on short circuit. Under the conditions of maximum available power, therefore, we obtain 20 volts and 2 ampères, or 40 watts. The stove with tin (fer-blanc) plates contains the same number of elements, and produces an electromotive force of 35 volts and 5 ampères on short circuit, or an available power of 44 watts.

Although the tin elements have a weaker electromotive force than the nickel elements, they offer less internal resistance, and are more cheaply manufactured, at the same time giving a few more available watts. It is these elements, therefore, that will be used for industrial purposes.

The apparatus we have been describing have been working and giving the results stated for more than three months. They thus constitute an interesting and ingenious application of thermo-electric batteries to the simultaneous lighting and heating of dwelling houses, and we wish all success to the inventor who has been the first to show experimentally the practical realisation of this idea.

LONDON COUNTY COUNCIL.

THE following report of the Highways Committee was presented at the last meeting:—

ELECTRIC LIGHTING PROVISIONAL ORDERS, 1891.

We have considered a letter from the Board of Trade stating, with reference to the Southwark Electric Lighting Order, that most of the amendments suggested by us on behalf of the council have been adopted; but there are one or two of those not adopted by the Board which in our opinion should be further pressed. We suggested the omission of the power of transferring the powers under the order to a company supplying an area within the City of London, as the provisions in the City orders relative to the council differ from those for areas outside, and some difficulty might arise in the event of amalgamation of the two undertakings. The Board does not consider this omission necessary; and, this being so, we have suggested that special provision should be made for keeping the accounts separate, and for ensuring that the council's powers under the Southwark Order shall not be diminished by amalgamation. There are two or three other minor amendments which appear to be required; and we have accordingly directed that the Board should be asked to consider those also. We recommend that our action with reference to the Southwark Electric Lighting Order be approved.

We have also had before us a letter from the Board of Trade with reference to the St. Luke's Chelsea Order, stating that most of the amendments suggested by us on behalf of the council have been made. Those not adopted by the board do not, in our opinion, relate to matters of very great importance, and we therefore do not propose that they should be further pressed.

SUBWAYS—REGULATIONS FOR THE USE OF.

We reported on the 28th April, that we were preparing and hoped soon to submit to the council, regulations applicable to all the council's subways. These regulations, which have been very carefully considered by us, are supplementary to the by-laws already made by the council under the Subways Act, 1868, and confirmed by the Board of Trade and the Home Secretary, and are intended to apply not only to the subways referred to in that Act, but to all others under the control of the council. We recommend that the council do make regulations in the following form:—

The London County Council, hereinafter referred to as the council, doth hereby make the following regulations, terms, and conditions, to be observed by any company, body, or person using a subway. Throughout these regulations the word pipe includes gas pipe, water pipe, wire, main, line, tube for wires or other tube and any apparatus connected therewith.

1. Fourteen days at the least before the date at which any company, body, or person proposes to lay a new pipe or to alter any existing pipe in a subway, notice shall be given to the council by such company, body, or person of the size, number, length, purpose, material and proposed connections of such new pipe, or of the proposed alterations, with particulars of supports and other works connected therewith, and plans and sections with details of the mode of fixing the same, and in the case of electric lines, the method of insulation.

2. Whenever any company, body, or person having a pipe in a subway desires to enter such subway, they or he shall give to the chief engineer of the council at least 24 hours' notice of such desire, and shall not (except in case of emergency) enter therein without the written consent of such engineer.

3. The keys of the subway entrances shall be kept at such places, and by such officials, as may from time to time be appointed by the council for the purpose; each company, body and person having pipes in the subways shall be supplied by the council with a card stating the places at which, and the names of the officials in whose custody the keys are kept, which card shall be produced to the official whenever application is made for access to a subway; and such officials shall arrange for the opening and closing, when required, of the gratings or covers for persons entering or leaving the subways, but it shall be the duty of the company, body, or person using a subway to provide a watchman for each grating or cover which is left open, and to temporarily fence or guard the opening.

4. The position of a pipe in a subway shall be subject to the approval of the engineer of the council, and if required the pipe must be supported independently of any other.

5. Except in cases of emergency a subway will only be opened between the hours of 6 a.m. and 5 p.m.

6. Each pipe placed in a subway shall, under the supervision of the council's chief engineer, be maintained by the company, body, or person to whom it belongs, and any damage done by such company, body, or person, or caused by, or by means of their or his pipes or pipe, to a subway or to any pipe therein shall be made good by them or him respectively; and in the event of a pipe or subway not being so maintained or made good, the council may have the necessary work executed at the expense of such company, body, or person, and the council will not hold itself responsible for any accident caused by the act or default of any agent or servant of the company, body, or person using the subway.

Should the above regulations be adopted by the council, it will be necessary for the council, in order to give proper and efficient facilities of access to companies and others using the subways, to appoint an additional subway inspector and an assistant inspector. The wages paid to the persons at present employed in these capacities are 35s. and 26s. a week respectively; and we recommend that an additional subway inspector at the wages of 35s. a week, and an additional assistant inspector at the wages of 26s. a week, be appointed; and that it be referred to the Highways Committee to select two persons suitable for the appointments.

Under the Subways Act of 1868, the council has no power to charge a rent to gas, water, and other companies using the subways specified in the Act, but it is empowered to make a charge for supervision. Under the Electric Lighting Orders and Acts, however, the council has power to require the electric lighting companies to lay their mains in the subways, and to charge a rent for the use of the subways, which rent must be agreed upon, or in case of difference, settled by an arbitrator to be appointed by the Board of Trade. We have prepared the following scales of charges in respect of each of these matters; and we recommend that the following scale of charges be approved by the council with reference to the use of the council's subways, and that the clerk be instructed to send copies of them to the companies and others concerned, with an intimation that the council will be prepared to consider any representations which they may wish to make with reference thereto:—

In cases where the council is authorised to charge a rent for the

use of any subway, it is willing to accept payments on the following scale from any company, body, or person using a subway; and any company, body, or person using any such subway without making any other agreement shall be deemed to agree to payment for such use upon the said scale.

SCALE OF ANNUAL RENT TO BE CHARGED BY THE COUNCIL UNDER THE ELECTRIC LIGHTING ORDERS AND ACTS, 1889, FOR THE USE OF A SUBWAY BY ELECTRIC LIGHTING COMPANIES:—

Name of subway.	Length in yards about.	Charge in Respect of a Pipe. (A pipe includes a wire, main, *line, tube for wires*, or other tube.) Internal diameter of pipes.			
		3 inches and under.	Over 3 and under 6 inches.	6 to 12 inches.	12 to 18 inches.
		£ s.	£ s.	£ s.	£ s.
Garrick Street	130	2 0	3 10	4 0	5 0
Commercial Road East .	380	5 0	9 10	11 0	14 0
Northumberland Avenue	310	4 0	8 0	9 10	12 0
Southwark Street ...	900	12 0	22 10	26 0	34 0
Shaftesbury Avenue ...	900	12 0	22 10	26 0	34 0
Charing Cross Road ...	900	12 0	22 10	26 0	34 0
Queen Victoria Street...	1,200	15 0	30 0	35 0	45 0
Victoria Embankment...	2,230	30 0	56 0	65 0	84 0

These charges are for the use of the entire length of a subway. Proportionate charges will be made for shorter lengths.

In addition to the above the charge for supervision for each day or part of a day during which a pipe is being laid or renewed shall be 5s.

The charge for opening or closing any subway at any time other than that fixed for the daily visit of the council's inspector shall be 1s.

NOTICES UNDER ELECTRIC LIGHTING ORDERS AND ACTS.

We have considered a notice dated 24th April, 1891, from the Kensington and Knightsbridge Electric Lighting Company of proposed extension of mains in Sussex Villas. There is no objection to these works, and we recommend that the sanction of the council be given to the works referred to in the notice dated 24th April, 1891, of the Kensington and Knightsbridge Electric Lighting Company.

The House to House Electric Light Supply Company has also given a notice, dated 25th April, 1891, of a proposed extension of mains in Lexham Gardens. The proposed works are unobjectionable, and we recommend that the sanction of the council be given to the works referred to in the notice dated 25th April, 1891, of the House to House Electric Light Supply Company, upon condition that the company do give two days' notice to the council's chief engineer before commencing the work; that no pipes of a larger diameter than 6 inches shall be used; that the mains shall be laid under the footways wherever it is found practicable do do so; that the street boxes to be used shall be of the pattern approved by the council; and that, as an additional precaution against accident through defective insulation of the mains, each of the street boxes shall be provided with an inner as well as an outer cover, each insulated from the other as far as practicable, and that the outer cover shall be efficiently connected with earth.

We have also to report the receipt of the undermentioned notices given by the Electricity Supply Corporation, in accordance with the resolution of the council to accept four days' (instead of one month's) notice in respect of laying the service lines from mains already laid:—27th April, 1891—To 447, Strand; 28th April, 1891—To 6, Grand Hotel Buildings.

PARLIAMENTARY NOTES.

THE SIMS-EDISON TORPEDO.

MR. GOURLEY, the other night, asked the First Lord of the Admiralty whether his attention had been called to the public trial of the Sims-Edison torpedo made at Havre on Saturday last; if so, whether he would state the difference (if any) between that and the Brennan torpedo; whether it was true that the Sims-Edison torpedo could be steered in any course over two miles at the rate of 20 miles an hour, and that it was capable of cutting through any net, and also of destroying the heaviest ironclad; and whether he intended having experiments made with it at Portsmouth or elsewhere.

Lord G. HAMILTON: The Sims-Edison, like the Brennan torpedo, is not of a type considered suitable for use by ships at sea, and no experiments with it will, therefore, be carried out by the Admiralty. The trials have been attended by officers acquainted with the Brennan torpedo, and its capabilities, in comparison with that weapon, will doubtless be reported on and considered.

SUNDAY DUTY IN THE POST OFFICE.

In answer to Mr. CAREW,

Mr. RAIKES said: The Treasury Minute of July, 1890, authorised additional payment for Sunday duty to sorting clerks and telegraphists, and I am not aware of a single instance in which the money has not been paid. If the hon. member can mention any case in which it has not been paid, I will enquire into it.

ELECTRIC LIGHTING AT BATH.

AT a meeting of the Town Council last week, the following report with the remarks and recommendations of the Electric Lighting Committee was submitted:—"The minor defects noticed by Prof. Forbes have been corrected. Prof. Forbes recommends our present ground glass globes. Your committee have tried the effect of clear glass globes, but do not consider the result favourable. They hope Mr. Massingham will at once remove the loose coils and be very strict in seeing to the cleaning of the glass globes. The delay in presenting this report has arisen owing to a correspondence with Prof. Forbes respecting paragraph 2, in which he says that 'the total quantity of light given out by each arc lamp is certainly not more than the total quantity given out by three or four hundred normal candles.' The correspondence resulted in Prof. Forbes stating that 'I think it very probable that when one of the nominal 1,200 C.P. Thomson-Houston arc lamps is tested at the angle at which it gives a maximum illumination, it may, under the best possible circumstances (such as are chosen for the testing of gas) give an illumination of 1,200 candles." In the professor's "General Remarks" he says:—"I believe that the contract with Mr. Massingham has been properly carried out. I see every reason to believe that the private lighting can now be maintained in a very satisfactory condition, except for the absence of the automatic means," mentioned above. "The public arc lighting," the professor says, "is as satisfactory as could be expected from the terms of the contract," but he does not consider the Bath installation equal to that of many of the continental and American towns, either in "quantity or quality," the professor preferring the 10 ampère to our 6·8 ampère lamps, and he would place the lamps nearer together. Your Electric Lighting Committee ask the authority to adopt Prof. Forbes's recommendations:—(1) To retain a competent electrical engineer to make periodical visits—once a quarter—in order to test the condition of the circuits, to examine the street lighting and to note the constancy of the electric pressure of the incandescent lamps; and (2) To authorise them to supply a few additional arc lamps to those parts where the lights are now too far apart.

After a long discussion, in which differences of opinion were expressed upon the subject, the report was adopted.

THE SILVERTOWN PATENT PORTABLE TESTING SET.

THIS set has been designed for the use of electrical engineers for testing insulated conductors for conductivity and for insulation. The apparatus is contained in two boxes, of which one holds the batteries, and the other the galvanometer, resistance coils, and proportional parts of a Wheatstone bridge, key, high resistance coil, and a set of galvanometer shunts. The instruments are arranged in their box, and connected up together, so as to economise space, and in order that the tests can be taken with a minimum of trouble and waste of time.

The battery box is fitted with two sets of elements; one, for use with the bridge, is made up of four Leclanché cells of low resistance, the other part is a set of 30 small Leclanché cells, having a total electromotive force of 45 to 50 volts, which should be exclusively employed for making insulation tests. This is called the insulation battery, and is subdivided into three sections of ten cells each, so that the electromotive force can be varied. The connection between the battery and the instruments is made by plugs attached to the ends of the battery leads, which fit into suitable holes in the instrument board. The adjustable resistance of the bridge consists of two sets of nine coils, arranged in dial fashion. One set of coils has resistances of 10 ohms each, and the other of one ohm each, or a total for the two sets of 99 ohms. The proportional resistances are of 10, 100, and 1,000 ohms each, similar to the ordinary P.O. pattern. The galvanometer has a pivoted needle with an aluminium pointer which can be easily removed by withdrawing a slide from the inside of the coil. The scale is one of equal currents, and is obtained by calibrating the instruments. A controlling magnet is also provided to regulate the sensitiveness of the galvanometer over a range of about 40 per cent. of variation, and it can be used to adjust the needle to zero. The galvanometer is put in circuit by pressing down an ordinary tapper key. It is rather a pity that a second key was not provided for the battery circuit, instead of having to take out a plug each time the battery circuit requires breaking.

For making insulation tests, which are taken by the direct deflection method, there is provided a resistance coil of 10,000 ohms, and a set of shunts multiplying 5, 20 and 100 times.

By means of the Silvertown portable testing set, resistances can be measured varying from ·01 to 10,000 ohms, while insulation resistances up to perhaps 100 megohms can be dealt with.

The company have published a little book descriptive of the set, which enters fully into the best method of using the apparatus, cautions the operator against certain contingencies conducive to the damage either of the battery or of the galvanometer, gives diagrams of all connections necessary to be employed in the several tests, and within the compass of its few pages embraces and describes in lucid phraseology all that can possibly be required by the veriest novice to enable him to carry out all those tests for which the instruments were designed.

NOTES.

Leeds and the Electric Light.—Arrangements are now practically completed by the Leeds Corporation with the Yorkshire House-to-House Company for a supply of electric lighting for that borough. The system to be adopted is the alternating high potential system. There will be one central station, probably near the river or canal, where all the manufacturing will be done. From that station the electric current will be sent out at an energy of about 2,000 volts. At various points in the area to be supplied there will be sub-stations, in which transformers, or converters, will be placed. From these converters the electric energy will be distributed to houses and shops at 100 volts, incapable of imparting a shock even when the wires are touched. All mains are to be laid underground. The service wires from the mains into the houses must be provided at the cost of each individual customer or the landlord—as in the case of a gas supply. Meters will be charged for separately. The company have agreed with the corporation to allow discounts on the full number of lamps required. These discounts would thus work out: For 500 hours' use per quarter, under 6½d. per unit; for 1,000 hours, 5½d. per unit. The electric light ought to be supplied by the company at an average of 6d. per unit, and if it had been kept in the hands of the corporation, it could have been supplied at 4d. per unit. This has been proved by the installation in the Leeds Fine Art Gallery. It has been calculated that, for house or shop purposes, a 5-light installation will cost about £7 10s.; a 10-light, £12 10s.; and for 100 lights, about £1 per light. This includes all wires, switches, fuses, lamps and casing—but not electroliers, which may be cheap or costly, according to the wishes of the consumer. As to the Yorkshire House-to-House Company, no doubt exists that the terms made with them are as valuable as could be obtained; and that they will be in a position to carry out the electric lighting of Leeds in a very satisfactory manner. The company will be an independent branch of the House-to-House Company, started in 1880.

Personal.—We are informed that Messrs. Cole, Marchent and Morley, engineers, of Bradford, have appointed Mr. Wilson Hartnell, of 11, Queen Victoria Street, E.C., as their agent for all classes of general engineering, oil, mill machinery, &c. Messrs. James Lee and Sons, leather belting manufacturers, of Hipperholme, near Halifax, have also appointed the same gentleman to act in a similar capacity for their well-known best leather belting and Lee's patent link belting, &c.

What is It?—A "Ten Years' Subscriber" writes:—"Will you be so kind as to tell me the nature of the enclosed substance? It is used in Drake and Gorham's secondary cells, in pieces about the size of peas, which are packed between the plates, probably to prevent buckling. Unfortunately they also prevent the insertion of an acidometer. The cell from which enclosed sample was taken is one of a battery on an electric locomotive." The material sent is, we believe, a silicate manufactured by a special process, Dujardin's. It is porous, and is used as a separator between the D and G plates.

The Cost of Electric Lighting.—The Royal Scottish Society of Arts held its twelfth ordinary meeting in Edinburgh on Monday evening. A paper was read by Prof. Kennedy, engineer-in-chief to the Westminster Electric Supply Corporation. He gave a description and comparison of the systems of electric lighting at present in use in London. The lecturer remarked that there were a number of electric companies in London, and the intention of each company was to supply the electric current as gas companies supplied gas. They built central stations in which the electricity was generated and laid mains along the street. The companies in London might be classed as those using the high or low pressure in their mains, or as those using what was called the continuous or the alternating current. He did not think that any one system presented all the necessary merits, as the system which was best for one district was not suitable for another. Regarding private lighting, he said so much depended upon the amount of economy exercised in the use of electricity that the cost might not be much more than that of gas, or it might exceed gas at 3s. by 25 or 30 per cent.

Seeing is Believing.—A telegram by Dalziel's agency, dated Chicago, May 13th, says:—Mr. Edison arrived here yesterday, and was entertained by some members of the World's Fair Commission. In course of conversation, the great inventor was asked if he had not got an electrical novelty in store for the Columbian Exhibition. Mr. Edison replied: "It is my intention to have ready for the World's Fair such a happy combination of photography and electricity as will enable a man to sit in his own parlour and behold depicted upon a curtain before him the forms of the players in an opera upon a distant stage, and to hear the voices of the singers. When the system is perfected, which I hope will be in time for the fair, each little muscle in the singer's face, every glance of the eye, and each expression will be seen at work. Every colour in the performer's attire, too, will be exactly reproduced. Moreover, the spectator, seated by his own fireside, will see each person in the play move to his or her position in a natural way, just as though they were the very persons themselves." Mr. Edison went on to say that it will be possible to apply, ere long, this system of combined electricity and photography to prize fights, so that the whole scene, including the noise, the blows, the talk, the dust, and every movement will be transferred and reproduce itself in the spectator's presence.

Telephones in Manchester.—On Friday last, before Mr. Justice North, Mr. Cozens Hardy, Q.C., M.P., on behalf of the National Telephone Company, asked that a motion for an injunction against the Mutual Telephone Company, Limited, should stand over so that certain of the defendants' affidavits could be answered.—Mr. Napier Higgins, Q.C., for the defendants, said:—I think that if the facts were before your lordship now in detail your lordship would desire that some person should be appointed to see whether in a particular way certain things can be done or not. We are perfectly willing at once, without going to the enormous expense of discussing about possible contacts in 50 or 60 places, that some person should be appointed by the Court to ascertain and pronounce upon the facts and the possible remedies on both sides.—Mr. Justice North: The plaintiffs are now advised of your willingness in that matter, and they can act upon it if they like.

Funeral by Electric Light.—The *West Middlesex Standard* notes that on Tuesday, the 5th inst., at the quaint old church in the grounds of Twyford Abbey, near Ealing, Middlesex, which has been recently electrically lighted by Ronald A. Scott, of Acton Hill, the remains of Mrs. Margaret A. Douglas-Willan, of Farquhar Road, Norwood, were interred in the family fault. The vault, which contains 14 coffins, and extends 30 feet under the old abbey church, was brilliantly illuminated with incandescent lamps. The effect was striking in the extreme; and every screw-head and nail in the old oak coffins (some over a hundred years old) could be easily distinguished. It is believed that this is the first funeral in which the electric light has been used to illuminate vaults. Now we understand why the suppliers of electric light were dubbed "undertakers" by those responsible for the Electric Lighting Act.

Manchester Town Hall Lighting.—We see from an advertisement that it is intended to electrically light the Town Hall at once, and before the Town Lighting can come into effect. The Gas Committee is prepared to receive tenders, divided under two heads, and those who are desirous of competing can, we suppose, gain all the necessary information from the Town Clerk, Mr. Wm. Henry Talbot.

Finsbury Technical College Conversazione. — The Hon. Sec. of the *Conversazione* Committee writes to us as follows :—"I wish to call attention to a mistake in the reference in your last issue to the *conversazione* at Finsbury College on May 15th. With the exception of the concert, which you correctly state will be given by the Musical Committee of the Old Students' Association, the *conversazione* is planned and given by the present students of the college."

Telegraphic Facilities for Orkney. — The telegraph steamer *Monarch*, from the Thames, arrived at Rackwick, Hey, last Friday, in order to repair the Pentland Firth cable. The cable was put right on Monday and communication restored. The *Monarch* then proceeded to Westray to lay the new cable recommended by the West Highland and Islands Commission, and another to Shetland between Lerwick and Bressay.

Ship Lighting.—Mr. R. D. Smillie, electrical engineer, West Regent Street, Glasgow, has secured the electric lighting of the paddle steamer at present being built in Messrs. Blackwood and Gordon's yard, Port Glasgow, for the Dublin Steamship Company. The installation is to be of an exceptional character, with all the most modern improvements. We are informed that Mr. Smillie has severed his connection with Messrs. Holmes (whom he acted for in Scotland), owing to the rapid increase of his own business, which now demands his undivided attention.

Hotel Lighting in Egypt.—One of the most successful installations of electric lighting may be now seen working at the Mena House Hotel, Cairo, where there are 350 incandescent lamps fitted. The plant was erected by Mr. A. J. Howes, of London, who has had the entire management and control of the work throughout. The engine is a compound engine by Marshall & Co., of Gainsborough, of 45 indicated horse-power, and there are two compound dynamos by Mackie, of London. The engine room is 260 yards from the hotel and the current is conveyed by means of a lead-covered cable laid in asphalt as a protection during high Nile. The whole light at Mena has given universal satisfaction.

Willans and Robinson.—The works of Messrs. Willans and Robinson at Thames Ditton are a scene of wonderful activity, the business continuing to increase by leaps and bounds. An extensive new erecting shop is just coming into use, and here may be seen from thirty to forty engines of from 200 H.P. to 300 H.P., simultaneously approaching completion. The Willans engines at the Naval Exhibition represent a total of over 1,000 H.P., and it seems only appropriate that such a prominent position should be allotted at this Exhibition to this make of engines, in view of the very large extent to which they are now in use in the Royal Navy for driving electrical machinery.

Cost of Power Transmission. — The following comparisons of the cost of transmitting power by various methods appeared in the *Revue Universelle des Mines:* 1. Comparative cost on 10 E.H.P., transmitted 1,093 yards: by cables, 1·77; by electricity, 2·21; by hydraulics, 2·90; by compressed air, 2·98. 2. Comparative cost on 50 horse-power, transmitted 1,093 yards; by cables, 1·35; by hydraulics, 1·87; by electricity, 2·07; by compressed air, 2·29. 3. Comparative cost on 10 effective horse-power, transmitted 5,465 yards: by electricity, 2·64; by compressed air, 4·66; by cables, 4·69; by hydraulics, 5·29. 4. Comparative cost on 50 effective horse-power, transmitted 5,465 yards: by electricity, 2·37; by cables, 2·65; by compressed air, 2·99; by hydraulics, 3·02. Steam was the prime motor used in each of the above instances, and it appears that for long distances electricity takes the lead in economy over all other systems.

Yacht Electric Lighting. — On Saturday last Messrs. Ramage and Ferguson, Leith, launched from their yard a beautifully modelled steel steam yacht for Mr. John Anderson, Glasgow. The vessel will be furnished throughout artistically and luxuriously, and with a complete installation of electric light.

Institution of Electrical Engineers' Students.—A general meeting of the students of the institution was held on Friday, May 8th, when a paper was read on "Magnetism," by Mr. C. O. Lloyd. The next meeting will take place on Friday, May 22nd, when Messrs. Griffin will read a paper on "Arc Lamps."

The Execution by Electricity Appeal.—A telegram from Washington, dated May 12th, runs as follows :—The appeal of the four murderers who were sentenced to be executed by electricity some months ago, came before the Supreme Court to-day. The Court overruled all the pleas set up in support of the appeal, and directed the Clerk to issue the mandates for the execution at once.

Barnet Lighting.—Tenders for the lighting of the district for terms of three, five, or seven years are required for the Barnet Local Board. No particular method of lighting is specified. Tenders should reach Mr. H. W. Poole, clerk, 85, High Street, Barnet, by first post on 19th inst., marked on the cover "Lighting." Further particulars can be obtained upon application either by letter or by a personal interview.

Manchester Technical School.—A summer course of lectures in "Electrical Engineering" commenced yesterday. The lecturer is Mr. W. Stuart Harrison, of the Postal Telegraph Department, Manchester, and Silver Medallist and Triple First Honours in Electrical Engineering (City and Guilds of London Institute). This course is specially arranged for students in the higher branches of electric lighting and transmission of power, and will comprise ten lectures, each lasting one and a-half hours.

South American Traffic and the French Cables.—We extract the following from *Le Matin* of May 5th :—"The TELEGRAPHIC JOURNAL AND ELECTRICAL REVIEW expresses bitter regrets that the French Submarine Cable Company should have succeeded in establishing itself in the West Indies and South America while ousting its English competitors. The journal we refer to estimates the yearly traffic of South America at 7,500,000 francs, of which amount the French Company would obtain the greatest share. This estimate exceeds the modest calculations of the company, which is contented to estimate its receipts at 2,050,000 francs, in addition to 355,000 obtained from subventions and guarantees."

Recent Interruptions and Repairs to Submarine Cables and Land-Lines up to April 25th, 1891 :—

Cables—	Date of interruption.	Date of repairs.
Jamaica - Peurto Rico—Santa Cruz	15th Dec., 1890	2nd March, 1891
Para—Maranham	10th Feb., 1891	6th " "
Trinidad—Demerara	11th " "	3rd " "
Constantinople—Dardanelles..	16th " "	6th " "
Metelin—Aivali	20th " "	2nd " "
Ceara-Maranham	3rd March "	4th " "
Mollendo-Arica—Iquique ...	5th " "	Still interrupted.
Ceara—Pernambuco	14th " "	" "
Santa Elena—Payta	31st " "	3rd April, 1891
" "	8th April "	8th " "
" "	9th " "	13th " "
Marseille—Barcelona... ...	4th " "	14th " "
Chorillos—Mollendo	6th " "	7th " "
Land-lines—		
Transandine	8th January "	20th March "
Moulmein—Bangkok... ...	25th Feb. "	2nd " "
Indo-European	27th " "	28th " "
Moulmein—Bangkok... ...	18th April "	22nd April "
Saigon—Bangkok	21st " "	25th " "

Paris Electric Lighting Company.—A contemporary says it hears that Woodhouse and Rawson are preparing for the public a company with this title.

Obituary.—We regret to learn that M. Edmond Becquerel, son of Antoine César Becquerel and father to Henri Becquerel, all three members of the Académie des Sciences, has just died at the age of 70 years.

Telegraph Materials.—The Great Eastern Railway Company requires a supply of telegraph materials. Forms of tender may be had on application to the secretary's office, Liverpool Street terminus.

New Business.—Messrs. Osborne & Co., Pleasant Place, Essex Road, N., have commenced business at the above address as electrical and chemical engineers, more especially to put upon the market a new form of primary battery. A set of cells measuring 12 inches by 8 inches by 8 inches (consisting of six small double fluid cells) is said to remain constant for 30 hours, giving an output of 20 ampères, at 9·5 volts, and having a drop of only 5 per cent. at the end of 26 hours. The chief expenditure is for the zincs, as the depolariser itself only costs 3d. per unit (1,000 watts). We should much like to examine the measuring instruments with which these results were obtained.

Alleged Refusal to Supply Electric Light.—Mr. Hanson applied at the West London Police Court on behalf of a client, for a summons against a company not mentioned, for refusing to supply the electric light. He said he made the application under the 26th section of the Act. His client had been supplied for 18 months, but on Tuesday the supply was stopped. An inquiry was made, and the answer received was that the supply could not be furnished in the day time. Mr. Plowden: Do you suggest it was wilful or accidental? Mr. Hanson: Wilful. They say they will not supply it in the day time. My client conducts his business in the day time and requires the light. Mr. Plowden granted the summons.

Centenary of the French Patent Law.—In view of the important centennial celebration of the establisment of the United States patent system, which was recently held at Washington, it is interesting to note that the Society of Consulting Engineers and Patent Agents are taking steps to celebrate the centenary of the French law as regards patents for invention, which was passed by the National Assembly on the 7th January, 1791, and which came into effect on the 25th May following. A committee, having at its head the president of the above-named society, has been formed, and efforts are being made to make the centennial celebration a success.

Electrical Transmission of Power in Mines.—Messrs. M'Whirter, Ferguson & Co., of the Faraday Electrical Works, Govan, have just completed an order for the electrical transmission of power for mining work for Mr. John M'Culloch, of Loganlea Collieries, near West Calder. A dynamo capable of yielding 60 electrical H.P. at a pressure of 200 volts has been supplied, the current from which will be carried down the mine in cable manufactured by the Fowler Waring Company. Descending the shaft, the first branch from the cable will be carried to a small motor used for hauling. At the bottom of the mine a large road—to be used in working the main seams—is being driven through the solid stone. A motor of 30 horse-power will do the bulk of the hauling here. The water met with in the construction of the road will be pumped to the surface by means of another motor of 15 horse-power. When the installation is complete it is estimated that Mr. M'Culloch will have at his command about 150 horse-power, capable of being applied not only to the purposes mentioned but to rock-drilling, coal-drilling, and coal-cutting. It will also serve to light up the whole of the extensive works. The installation at Loganlea, it is believed, is the first of its kind in Scotland.

NEW COMPANIES REGISTERED.

City of Bath Electric Lighting and Engineering Company, Limited.—Capital £60,000, divided into 5,500 ordinary £1 shares and 50 founders' £100 shares. Objects: To adopt an agreement with Mr. H. G. Massingham, dated the 2nd inst., to supply electric light within five miles of the City of Bath; to manufacture and put up telegraphs, telephones, electric bells, phonographs, &c.; and to acquire and carry on the business of manufacturers of lightning conductors, electrical generators or accumulators, lamps, lamp-posts, electric light elevators, engines, and all kinds of electrical apparatus and appliances. Signatories: Lieut.-Colonel T. Vaughton, 7, Cavendish Place, Bath, 50 shares; Major-General J. G. Jervois, Bath, 50 shares; A. Pitman, 12, Royal Crescent, Bath, 50 shares; E. B. Titley, Bath, 50 shares; H. N. Garrett, 101, Sydney Place, Bath, 50 shares; E. Pitman, 12, Royal Crescent, Bath, 50 shares; W. Jeffery, 2, Northumberland Buildings, Bath, 10 shares. The number of directors is to be five, the first being Lieut.-Colonel T. Vaughton, H. N. Garrett, A. Pitman, Major-General J. G. Jervois and H. G. Massingham. Qualification £500. H. G. Massingham is the first managing director. Registered on the 6th inst. by Kingsford, Dorman & Co., 23, Essex Street, Strand, W.C.

Roper's Electrical Engineering Company, Limited.—Capital £15,000, divided into 10,000 ordinary and 5,000 preference shares of £10 each. Objects: To purchase and develop the business of mechanical and electrical manufacturing engineers, known as Roper's Electrical Engineering Company (late John and William Roper), of Trafalgar Works, Trafalgar Street, Bradford, York; and to carry on the business of manufacturers and dealers in electric, telegraphic, surgical, and scientific instruments, dealers in and suppliers of electrical engineering, and also that of an electric light and supply company. Signatories (with one share each): H. R. Carr, 213, Cardigan Lane, Leeds; H. Woffinden, 35, Moor View, Leeds; E. Robinson, 9, Vernon Road, Leeds; F. W. Ames, 68, Boynton Street, Bradford; A. Trohon, 77, Princeville Street, Bradford; A. W. Hine, 14, Trafalgar Street, Bradford; F. J. A. Matthews, F.G.S., Hilly Ridge House, Headingley, Leeds. Registered on the 6th inst., without special articles, by J. M. Urquhart, 10, Denbigh Street, Warwick Square, S.W. Office, Trafalgar Street, Bradford.

European Sims-Edison Electrical Torpedo Company, Limited.—Capital £201,000, divided into 10,000 ordinary shares of £20 each, and 1,000 founders' shares of £1 each. Objects: To carry on the business of an electrical company in all its branches; to acquire patents and other rights granted to or belonging to Sims and Edison, of New York, relating to torpedoes; to carry on the business of electricians, electrical contractors, torpedo manufacturers, electrical and mechanical engineers, suppliers of electricity, and of manufacturers of and dealers in all apparatus required for the generation, distribution, supply, accumulation, and employment of electricity. Signatories (with one ordinary share each): E. H. Edwards, 30, Pellerin Road, Stoke Newington; E. Sorrell, Oak Cottage, Fowler Road, Forest Gate; J. Andrew, 15, Marriott Road, Tollington Park, N.; A. M. G. Carter, 40, Denning Road, Hampstead; R. H. Ibotson, 37, Chatham Road, Wandsworth Common, S.W.; W. Brown, 121, Hungerford Road, N.; S. Woodham, 82, Eveline Road, S.E. The number of directors is not to be less than three nor more than twelve, the first to be elected by the subscribers. Qualification, the holding of stock or shares. Remuneration to be determined at the general meeting. Registered on the 9th inst., by J. Andrew, 15, Marriott Road, Tollington Park, N.

Fowler Insulator Syndicate, Limited. — Capital £6,000, divided into 5,500 ordinary and 500 deferred shares of £1 each. Objects: To adopt an agreement dated the 25th of April, 1891, between J. Fowler and S. Wade, for the purchase of the patent for "insulators and appliances for suspending wires on aerial telegraphs"; to carry on the business of civil, mechanical, and electrical engineers; and in particular to manufacture, produce, and deal in insulators, as used in the telegraph and telephone services. Signatories

(with 1 share each) : A. H. Bacon, 10, Old Jewry Chambers, E.C. ; J. Black, 37, Walbrook, E.C. ; A. Rolfe, 76, Santley Street, S.W. ; J. S. Coleman, Grecian Chambers, Temple ; E. J. Gust, 12, South Crescent, Bedford Square, W.C. ; L. J. Arbuthnot, 108, Netherwood Road, West Kensington Park, W. ; G. Fowler, Selwyn House, Norwood, S.E. The number of directors is not to be less than two nor more than five. Qualification 50 shares. Remuneration £500 per annum between them. Registered the 6th inst. by R. Hewlett, 31, Essex Street, Strand.

Boy Messengers and Electric Call Company, Limited.—Capital, £200,000 in £1 shares. Objects : To acquire the business, assets, and goodwill of the Boy Messengers, Limited, and to work the messenger and electric call system in the City and County of London and elsewhere, within a radius of five miles from the General Post Office, and in other places. Signatories (with 1 share each) : P. B. Lyon, Members' Mansions, Victoria Street, S.W. ; R. V. Leonard, 58, Elsham Road, Kensington ; R. King, 3, Old Sergeant's Inn, W.C. ; L. D. Tottenham, St. Leonard's-on-Sea ; C. R. Langham, 1, Fairmead Road, Holloway ; J. L. Burr, 4, Church Street, Rotherhithe ; T. Guyatt, 3, Lorne Road, Stroud Green, N. The number of directors is not to be less than three nor more than twelve, of which one may be a director of the Exchange Telegraph Company, Limited. The first directors are Captain W. H. Davies, Lord F. Hamilton, Sir F. Milner, Bart., M.P., and Hon. P. B. Lyon and R. King after allotment. Qualification, 100 shares ; remuneration not exceeding £2,500 per annum. Registered on the 7th inst. by P. B. Lyon, Members' Mansions, Victoria Street, S.W.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Crompton-Howell Electrical Storage Company, Limited.—The annual return of this company, made up to 25th ult., was filed on the 28th ult. The nominal capital is £19,600, divided into 19,000 ordinary shares of £1 each and 6 founders' shares of £100 each. 12,007 ordinary and 6 founders' shares have been taken up, and upon 4,007 of the ordinary 15s. per share has been paid ; upon 8,000 of the ordinary 15s. per share has been considered as paid, and upon the founders' shares £600 has been considered as paid. The calls paid amount to £3,004 10s., considered as paid to £6,600, and unpaid to 15s. Office : Mansion House, Buildings, Queen Victoria Street, E.C.

CITY NOTES.

The Chelsea Electricity Supply Company, Limited.

THE directors beg to submit to the shareholders the report and statement of accounts for the year ending 31st December, 1890.

The accounts are not issued in Board of Trade form, because that course would involve two separate balance sheets (one for Chelsea and one for Kensington), which would be confusing to the shareholders. This is the subject of correspondence with the Board of Trade, and, when the matter is settled, the accounts will at once be put into such form as that department may require.

The steady progress of the business during the year is very satisfactory. On 31st December, 1889, 93 customers, or an equivalent of 8,730 lights of 8 candle-power, were being supplied ; while on 31st December, 1890, there were on the books 252 customers, with lights installed equivalent to nearly 20,000 lamps, of 8 candle-power.

The company has received for current sold and meter rents in 1890 the sum of £6,067 6s. 10d., and after deducting all working expenses, there remains a gross profit of £542 19s. 5d.

The consumption of fuel in the year 1890 has been excessive ; but this is believed not to be due to any defects in the Chelsea system, and measures have been taken which it is hoped will prevent its continuance.

The rate at which the revenue has increased is best exemplified by comparing the two heaviest quarters of the year. In March quarter the receipts for current supplied and meter rents amounted to £1,275 12s. 3d. and in December quarter to £2,872 17s. 6d. This affords an indication of the rate of increase of revenue in 1891 ; and, as the profits should be more than proportionately augmented, the prospects for the current year are favourable.

Under the authority given at the last general meeting, the directors resolved to issue £20,000 of 6 per cent. debentures, the whole of which has been subscribed. This has enabled the directors to repay the loan from its bankers, and to complete the extensions in hand last year, including new mains, and the new storage station at Pavilion Road.

In view of the further extensions necessary to occupy the areas within the company's districts, the directors have decided, in lieu of issuing any further debentures at present, to recommend an issue of preference shares, and, with this object, a resolution will be proposed at the general meeting of the company.

The completion of the plant in accordance with the original plan of the central station in Draycott Place is in progress, and when the work contemplated for the year has been done, the stations will be capable of earning over £100 during average lighting hours in one day. The experience gained by the company shows that under the varying conditions of demand throughout the year in this district, this earning capacity may be estimated to yield a gross revenue of about £16,000 per annum. After paying all outgoings, including the cost of upholding the plant, and interest on debentures, the balance should afford satisfactory dividends on the share capital.

The mains, consisting of Callender's bitumen cable, of which about 20 miles have been placed underground, are regularly tested, and the results continue to be most satisfactory on all the cables, including many which have been underground for two years. None have had to be renewed on account of defects.

The accumulators are all in good working order. Those at Clabon Mews storage station, which have been longest in use, *i.e.*, for two years, are in excellent condition, and it has not as yet been necessary to replace any of the plates.

The directors have not dealt with depreciation in these accounts ; but care has been taken to keep up all the plant to its original working efficiency. The storage batteries, which constitute a very large proportion of the plant, are under entirely new conditions as regards their working and supervision, and, until experience shows what provision is necessary, a renewal fund will be maintained out of the profits, in order to make provision for exceptional outlay in any one year.

The directors have to report the retirement of Lord Thurlow from the board of the company, and the election of Mr. Emile Garcke (managing director of the Brush Electrical Engineering Company, Limited), to fill the vacancy, subject to the confirmation of the shareholders. Mr. J. Irving Courtenay has been elected chairman of the company, and Major-General Webber, C.B., deputy-chairman, while still retaining the post of managing director.

The retiring directors are Mr. J. Irving Courtenay and Sir George Prescott, Bart., who, being eligible, offer themselves for re-election.

The auditors, Messrs. Cooper Brothers & Co., also offer themselves for re-election.

ABSTRACT OF ACCOUNTS for the year, to 31st December, 1890.

PROFIT AND LOSS ACCOUNT.

Dr.	£	s.	d.
To Generation of electricity, &c.	3,143	19	11
„ General charges	2,139	6	10
„ Renewals of plant and building	253	6	3
„ Balance down	542	19	5
	£6,079	12	5

Cr.	£	s.	d.
By sale of current, &c.	6,067	6	10
„ Interest on deposits	11	13	1
„ Transfer fees	0	12	6
	£6,079	12	5

NET REVENUE ACCOUNT.

Dr.	£	s.	d.
To Interest on Debentures...	530	5	7
„ Suspense item paid off	125	0	0
„ Balance carried to balance sheet	67	3	7
	£722	9	2

Cr.	£	s.	d.
By Balance brought down	542	19	5
„ „ from last year...	179	9	9
	£722	9	2

GENERAL BALANCE SHEET.

Dr.	£	s.	d.
To Capital account	46,040	0	0
„ Debentures	15,350	0	0
„ Sundry creditors	3,986	10	7
„ Balance	67	3	7
	£65,443	14	2

Cr.	£	s.	d.
By Capital account	51,874	17	2
„ Cash at bankers'	2,035	11	11
„ „ in hand	33	14	8
„ Sundry debtors	3,712	0	1
„ Preliminary expenses, &c.	7,054	19	2
„ Stores on hand	732	11	2
	£65,443	14	2

Mr. J. IRVING COURTENAY presided at the ordinary meeting, held at the company's offices at Chelsea yesterday. He said: When we met last year the profit and loss account presented to you was for one quarter of the year only, and that the quarter of heaviest demand. There was then shown a small balance to the good, but no directors' fees had been paid. The amount received for current sold during 1890 was £6,067 6s. 10d., and the gross profit shown in the accounts before you is £542 19s. 5d. I may mention that the receipts for the March quarter in this year amounted to £3,275. But you will bear in mind that, although we are now supplying current to over 22,000 lamps as against 10,000 this time last year, the increase in revenue in respect of these lamps was only even partially felt in the last quarter of the year 1890; and, moreover, the profit on the year's work has been made in spite of most disadvantageous circumstances, which I will now deal with. I allude to the question of the heavy consumption of coal mentioned in the report. I regret to say that the consumption during the year has been excessive; but I am glad at the same time, to be able to inform you that the unceasing attention to the subject on the part of the management has resulted in the certainty of a reduction of the cost of producing the current as soon as the rearrangement of plant now in hand is complete. As the subject is still under discussion, it is not permissible for me at the present moment to say where, in our opinion, the fault lies, but I sincerely hope that an amicable settlement of the difference will be arrived at.

There is another point I must touch upon, because it has been the subject of some misrepresentation. Owing to the non-delivery of machines, which were ordered early in the year to provide for the winter supply, we were compelled, on a few occasions in December, when a heavy drain came upon us through continued foggy weather, to shut off our supply of current for a few hours in the daytime. Some of the plant having shortly after arrived, the constant supply was resumed on the 24th December, and maintained throughout the remainder of an exceptionally foggy winter. Now, unfortunate as this undoubtedly was, it still showed the advantages of the storage system; for, instead of stopping the supply suddenly, as might be the case without storage, we were able to give a full day's notice that we should cease supply for a few hours in the daytime, and thus prevented serious inconvenience to our customers. We may congratulate ourselves that we have still the record of not having once stopped supply of current during the hours when light is generally required, and I may also here add that our customers continue to express their entire satisfaction. You will find in the profit and loss account an amount of £253 6s. 3d. for maintenance of plant. This is made up of small repairs to the different kinds of generating plant, instruments and tools, and about £50 in wages to men cleaning out the accumulator cells. No expenditure was incurred in 1890 in replacing the E.P.S. storage battery plates, and up to the present day only one set out of 1,918 sets has had to be replaced, and that at a trifling cost. Now it must be borne in mind that the replacing of a set of plates is not merely maintenance, as in the case of repairs to a steam engine, but is a complete renewal of the cell, as the other parts for all practical purposes suffer no deterioration. The mains of the Callender Company have also fulfilled our expectations and have not cost us anything for the repairs of cables. Some of the cables have been underground for over two years, and from tests taken periodically it is found that they are still in perfectly good condition. The E.P.S. accumulators are for the first time being used in sub-stations under the direct supervision of our engineer, and so well have they performed their duty that it is difficult, even now, to settle what is a proper amount to set aside for their depreciation. It is intended, however, as stated in the report, to maintain a renewal fund out of profits, in order to provide for exceptional outlay in any one year. I now come to the present state of the business and its prospects. You will see by the balance sheet that the plant has been increased by the amount of £14,660 10s. 6d. The mains and the generating and storing plant have all had a share in this increase, but the greater part of it is to be found in the extension of mains, and the erection of a new storage station in Pavilion Road. These additions, together with the plant ordered this year, will enable us to supply sufficient power for about 36,000 8-C.P. lamps installed, which, at the rate of 9s. per lamp installed, would represent a gross income of £16,000 per annum; but this income would involve the extension of our mains as found to be necessary. Nine shillings per 8 candle-power lamp installed is the figure upon which our experience shows it is prudent to base our estimate of income. I am aware that this is a somewhat lower yield per lamp than that of companies in whose area of supply theatres, hotels, clubs, and shops are numerous, but the shops in Chelsea are now also coming on our list of customers. I think, however, it will be found in practice that the above figure fairly represents the yield per 8 candle-power lamp in domestic lighting. Such is mainly the lighting in Chelsea and Kensington. Our district is an excellent one. There is no part of the metropolis where rebuilding is more continually going on, and very few houses indeed in this neighbourhood, as you are aware, are built without being wired for the electric light. We have had added to our area of supply by the Board of Trade a very large portion of the parish of Chelsea, containing about 4,500 houses, including several localities favourable to the development of the business. I do not, however, wish to put before you a too sanguine view of our prospects. I have, therefore, had a careful estimate made of the probable increase during the year in the number of lamps to be supplied, and the result of enquiry points to our reaching a total of 35,000 lamps installed, provided we make the extensions referred to. It is a matter of satisfaction that, during a year of financial tightness, and even panic, we have been able to place all the debentures we offered, viz., £20,000, at a moderate cost. The money thus obtained has been carefully dealt with in the most economical manner, and by means of the new plant already obtained, and that on order, we can confidently look forward to a considerable economy in the working during the latter half of the present year. As has been mentioned in the directors' report, it will be necessary to provide funds for the extension of the mains and for additional plant to meet the increase in the company's business, and after full consideration the directors have resolved to recommend an issue of preference shares bearing 6 per cent. interest, and for the present to defer any further issue of debentures. We propose to take power to convert £30,000 of the unissued ordinary share capital into preference shares. This fresh capital will be called up gradually as required. When this expenditure has been made, the total issued capital of the company, including debentures, will be about £92,000, or, in other words, the total capital outlay of the company, including the cost of all stations, cables, and plant, will be, say, £2 12s. per lamp fixed. These figures will compare favourably with those of other companies, especially when it is remembered that our conduits have a carrying capacity for double the number of lamps I have mentioned. I beg to move the adoption of the directors' report and statement of accounts.

Major-General WEBBER seconded, and the resolution was carried. The retiring directors and auditors being re-elected, a proposition to the following effect was adopted:—"That of the unissued capital of the company, now amounting to 11,512 shares of £5 each, 6,000 shares of £5 each, and numbered 14,001 to 20,000 inclusive, shall be, and the same hereby are created and made preference shares, and that such shares shall confer on the holders thereof the right to be paid out of the profits of each year a preferential dividend for such year at the rate of £6 per cent. per annum and no more, and every holder of preference shares shall have one vote for every preference share held by him."

The West Coast of America Telegraph Company, Limited.

THE directors' report states that the balance sheet and revenue account for the year ending 31st December, 1890, show a gross income of this company of £65,323 15s. 4d., against £84,457 13s. 1d. for the year ending 31st December, 1889.

The addition of £517 10s. 3d. brought forward from the previous year makes a total of £65,841 5s. 7d., and deducting from this the debenture interest and all other charges, as well as the interim dividend of 3s. per share paid in July last, there remains the sum of £22,195 12s. 11d. Out of this amount the directors have transferred £16,000 to the reserve fund, bringing it up to £80,000, written off £1,000 from the value of the repairing steamer *Retriever*, and now recommend the distribution to the shareholders of a final dividend for the year 1890 of 2s. per share, payable on the 20th inst., leaving £2,195 12s. 11d. to be carried forward.

The cable with which the Central and South American Telegraph Company intends to compete with the line has been laid, but is not yet working in its entire length, owing to the revolution which has broken out in Chili.

In accordance with what was suggested at the extraordinary general meeting of shareholders, held on 1st September last, negotiations have been commenced with the object of strengthening the position of the company, and opening for it a source of revenue not otherwise obtainable.

The directors look upon the present as a period of transition, but expect that these negotiations will lead to a satisfactory result; meanwhile they do not consider it prudent to make a larger division of profits than that recommended in this report.

During the Chilian revolution which broke out in January last, and unfortunately still continues, the cables of the company have been cut by both Government and opposition forces; the company has, however, received partial compensation for the interference with traffic.

The repairing steamer is in readiness to connect the sections cut as soon as hostilities come to an end.

Mr. Henry Roberts and Mr. Alfred Marshall are the directors retiring in rotation, both are eligible, and offer themselves for re-election.

The auditor, Mr. J. Weise, of Messrs. Turquand, Youngs, Weise, Bishop, and Clarke retires, and is eligible for re-election.

The Western Counties and South Wales Telephone Company, Limited.

THE report of the directors for the year ending 31st December, 1890, to be presented to the shareholders at the sixth annual ordinary general meeting of the company, to be held at the Grand Hotel, Broad Street, Bristol, on Friday, the 15th day of May, 1891, at 2 o'clock, p.m., is as follows:—

The capital expenditure for the year ending the 31st December, 1890, was £24,415 15s. 6d. making a total of £164,409 12s. 2d. to date.

The gross revenue of the company for the year 1890, was £46,860 15s., against £39,046 19s. 6d. for the year ending 31st December, 1889.

The amount of income carried forward to next year's revenue, as representing sums received in advance for periods extending beyond

31st December, 1890, is £14,212 19s. 1d., against £12,292 19s. brought in from the previous year.

The whole of the company's plant has been fully maintained, and, where required, renewed, out of revenue. The company have continued to substitute, at considerable expense, a large amount of copper and bronze wire for iron, which has increased the efficiency and durability of the plant.

The working expenses, including maintenance and all working charges for the year 1890, have been £13,775 18s. 1d., against £11,936 18s. 5d. for the year ending 31st December, 1889.

	£	s.	d.
Balance of net revenue account	9,177	7	3
Dividend of 6 per cent. on the paid up preference share capital for the year ending 31st December, 1890	6,000	0	0
Balance for appropriation, as per statement at end of accounts	£3,177	7	3

The directors recommend that the reserve fund, now standing at £1,700, be increased by the addition of £500, and that the balance, £2,677 7s. 3d., be carried forward.

The number of subscribers to the exchange system, and of private line renters, has considerably increased, and the progress made during the year is considered to be most encouraging. The respective totals at the close of the years 1889 and 1890 were as follows:—

	Exchange.	Private.	Total.
December 31st, 1890 ...	2,875 ...	712 ...	3,587
December 31st, 1889 ...	2,392 ...	671 ...	3,063
Increase in 1890	483 ...	41 ...	524

The mileage of trunk and renters' wires, erected up to 31st December, 1890, was 5,018 miles; erected up to 31st December, 1889, 4,115 miles; the increase representing new business during 1890 being 903 miles.

In addition to the above, 160 miles of wire have been renewed during the year.

The company has increased its trunk system, so that on the 31st December, 1890, it had 470 miles of trunk pole lines connecting towns with each other, carrying 2,182 miles of wire, against 383 miles of pole lines, carrying 1,804 miles of wire, at the corresponding date in the previous year.

The continued rapid growth of the use of the company's extensive system of trunk lines will be seen from the following figures:—

	Calls.
4 months ending December, 1887	27,338
12 " " 1888	142,443
12 " " 1889	184,754
12 " " 1890	249,160

Each call is answered, so that the number of communications has been double these figures.

The foregoing figures form conclusive evidence of the increasing appreciation by subscribers and the public of the convenience and economy of telephonic intercommunication between towns, and represent a remarkable development of this branch of the company's business.

The company has continued to keep in view the importance of connecting the principal towns of their district with the metropolis, and arrangements with the National Telephone Company for the construction of a line putting Bristol and the South Western district and South Wales in direct communication with London have been frequently considered.

It is also intended to connect Bournemouth, Southampton and Portsmouth with London, *via* Winchester, Basingstoke and Reading, when the necessary arrangements are completed.

Mr. Charles Nash and Mr. Richard Cory retire by rotation, but are eligible for re-election.

Messrs. Hudson Smith, Briggs & Co., auditors, retire, but are eligible for re-election.

Western and Brazilian Telegraph Company.

MR. W. S. ANDREWS presided at the twenty-first ordinary general meeting of the Western and Brazilian Telegraph Company, which was held last Friday at Winchester House, E.C.

In taking the report as read, the CHAIRMAN stated that the receipts for the half-year ended December 31st last had again been satisfactory—viz., £108,817, or £22,414 in excess of those of the corresponding period of the previous year. The large increase was due to the speculation, the excitement, and the state of politics in the countries served by their lines. The half-year's expenses had been £37,200, or £3,191 less. Having given the details of the expenses, and drawn attention to the increased work done, he stated that they had not had to charter any ship this time, a fact which removed a charge of £8,531 from their accounts. This sum was, however, reduced to the net figure of £5,434 by the larger expenditure in connection with the company's own vessels, the *Norseman* and the *Viking*. Including the sum brought forward (£5,751), and the dividend on the Platino shares (£9,233), they had £86,602 to deal with, and deducting the debenture charges and £20,000 added to their reserve fund they had left £47,502, out of which they proposed a dividend of 9s. a year, making 5 per cent. for the year, which would require £41,432. He alluded at the last meeting to the loop lines which the Government had permitted them to lay. The tender for the work had been given to the India-Rubber and Telegraph Works Company. These lines really constituted a capital charge, but having no capital it had been decided to take the money required from the reserve fund, and then to fortify that fund by an issue of £50,000 of 4 per cent. debentures. They would then have £99,000 standing to the credit of the reserve fund. Their position would be greatly improved and strengthened by the loop lines. A scheme had at last been devised for dealing with the debentures, but the holders would have to be consulted. They were threatened with competition, but in their strong position he believed they would be able to hold their own. The present traffics, of course, must be regarded as abnormal, but he believed that, having the most direct and the best route, they would be able to maintain their normal receipts, even in the face of competition.

The report was adopted.

West India and Panama Telegraph Company.

THE ordinary meeting of the company, presided over by Mr. C. W. Earle, was held at Winchester House on Wednesday.

The CHAIRMAN, in asking the shareholders to consider the report as read (published in our last issue), said the meeting would constitute an epoch in the financial history of the West India Company. It would mark an epoch, because they would free themselves of the incubus of arrears on the preference dividends, which had been in existence since 1880. It would also mark an epoch in respect to paying the first dividend since 1878 to the ordinary shareholders, and which was the fourth paid since the existence of the company. He thought he ought to be allowed to express his admiration of the patience of the shareholders, who had borne so long with the unfortunate condition of affairs. He was justified in taking some credit to the board in having resisted the very numerous financial schemes that had from time to time been pressed upon them, and which, if adopted, would no doubt have left them to-day in a very much worse position than they were. Looking at the accounts, gross revenue was increased by £1,210, while the expenses had been decreased; that decrease was attributable to the absence of cable repairs. The increase of £1,210 was made up by several small items, and by an increase of £1,608 in traffics. As a set off against that, there was the diminution in the subsidy from Martinique. It was impossible to conceal from oneself that there was no growth or progress in the traffic returns in the West Indies. They saw there very different conditions to those in the Australian colonies, where there was a constant increase in the commercial industries. The West Indies, however, were islands of limited size, and they were not very new countries; it was pretty well known what can be got out of them, and there was not much room for industrial development or commercial growth. In such a condition of affairs it seemed to him quite clear that the telegraphs in the West Indies would always be restricted, and consequently always expensive. In spite, however, of this, they were threatened with competition, first from what was called a technical line, proposed for use in warfare, which, however, would be of no use, and also lines proposed to be laid by France. They would perhaps have noticed also that a gentleman connected with the Canadian telegraphs had been spending some time in the West Indies, telling the people that he would be able to lay cables and send messages at quarter of the rates charged by the West India Company; that gentleman, however, must have great faith in the gullibility of mankind if he thinks he can get people to subscribe money upon anything like the basis which he states. With regard to the Martinique subsidy, they had considered whether it was worth while to take any legal process against the colony for breaking the contract. The sum in question was £1,500; but after taking the best legal advice in Paris, and fully considering the whole matter, they thought it best to accept £500. Coming to the matter of laying a new cable between Demerara and Trinidad, they had decided to do this, as the colony promised a subsidy for ten years.

A resolution was then submitted to the meeting, in pursuance of the company's memorandum of association, to sanction the borrowing by the board of a sum of £100,000 for the purposes mentioned in the report, and the issue of securities for the same, and carried.

Bedford Electric Light Company, Limited.

THE annual meeting was held at the office of this company, on Saturday. Beyond the submitting of the balance sheet, which showed that £150 had been placed to deposit account at the London County and Bank, and that the total expenditure up to date amounted to £33 14s. 5d. only, the business was purely formal. The retiring director, Sir Henry Mance, was re-elected, and Mr. James Hull appointed auditor for the current year. In discussing the position of the company, the CHAIRMAN remarked that as promised at the previous meeting, they had been extremely careful not to spend a penny unnecessarily, and they would continue to follow this policy, so that if the company did not eventually undertake the lighting of Bedford the public would practically receive back their payments in full. In answer to a public invitation from the corporation to tender for lighting a certain area in the town, the company had submitted a proposal, which was still under consideration.

TRAFFIC RECEIPTS.

The Brazilian Submarine Telegraph Company, Limited. The receipts for the week ended May 8th, 1891, amounted to £4,961.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending May 8th, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brasilian Company, were £3,964.

SHARE LIST OF ELECTRICAL COMPANIES.

Present Amount Issued.	Name.	Stock or Share.	Closing Quotation. (April 30).	Closing Quotation. (May 14.)	Business done during week ending May 14, 1891. Highest.	Lowest.
250,000*l*	African Direct Telegraph, Ltd., 4 p. c., Deb. Regd. and to Bearer	100	99 —102	99 —102	...	...
1,381,380*l*	Anglo-American Telegraph, Limited	Stock	46½— 47½xd	47 — 48	48	47
2,809,310*l*	Do. do. 6 p. c. Preferred	Stock	84 — 85 xd	85— 86	86½	85½
2,809,310*l*	Do. do. Deferred	Stock	11¼— 12	12 — 12⅛	12⅛	12¼
130,000	Brazilian Submarine Telegraph, Limited	10	11¼— 12	11⅞— 12¼	12 1/16	11 13/16
84,500*l*	Do. do. 5 p. c. Bonds	100	101 —104	101 —104	...	...
75,000*l*	Do. do. 5 p. c., 2nd Series, repayable in June, 1906 ...	100	104 —108	104 —108	...	...
63,416	Brush Electric Engineering Ordinary, Nos. 1 to 63,416	3	2¼— 2½	2⅛— 2⅜	2 5/16	...
63,416	Do. do. Non cum. Preference, Nos. 1 to 63,416	2	1⅝— 1⅞	1⅝— 1⅞	1⅞	1 11/16
50,000	City and South London Railway, Nos. 1 to 50,000	10	5¼— 6¼	5 — 6	...	...
$7,216,000	Commercial Cable, Capital Stock	$100	108 —110	108 —110	109½	...
224,850	Consolidated Telephone Construction and Maintenance, Limited ...	14/-	7/16— 9/16	½— ⅝	...	...
20,000	Crompton & Co., Ltd, 7 p. c. Preference Shares, Nos. 1 to 20,000	Stock	4 — 5	4 — 5	...	...
16,000	Cuba Telegraph, Limited	10	10½— 11½	10½— 11½	10⅝	...
6,000	Do. do. 10 p. c. Preference	10	16½— 17½	16½— 17½	...	...
12,931	Direct Spanish Telegraph, Limited, ... (£4 only paid)	5	3¾— 4¼	3¾— 4¼	...	...
6,000	Do. do. 10 p. c. Preference	5	9 — 10	9 — 10	...	...
60,710	Direct United States Cable, Limited, 1877	20	10 — 10¼xd	10¼— 10½	10⅝	10¼
400,000	Eastern Telegraph, Limited, Nos. 1 to 400,000	10	14¼— 14½	14⅜— 14⅝	14⅝	14 7/16
70,000	Do. 6 p. c. Preference	10	15¼— 15⅝	15¼— 15⅝	15⅝	15⅝
200,000*l*	Do. 5 p. c. Debs. (1879 issue), repay. August, 1899	100	107 —110	107 —110	...	...
1,200,000*l*	Do. 4 p. c. Mortgage Debenture Stock	Stock	106 —109 xd	106 —106	107½	...
250,000	Eastern Extension, Australasia and China Telegraph, Limited ...	10	14⅜— 15¼	14⅜— 15¼	15 3/16	14 15/16
91,800*l*	Do. 5 p. c. (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	103 —106	103 —106	104	...
325,200*l*	Do. do. Bearer Nos. 1050—3,975 and 4,327—6,400 ...	100	104 —107	103 —106	104	...
320,000*l*	Do. 4 p. c. Debenture Stock	Stock	105 —108	105 —108	108½	106½
135,000*l*	Eastern and South African Telegraph, Ltd., 5 p. c. Mort. Deb. 1900 redeem. ann. drawings, Registered Nos. 1 to 2,343	100	103 —106	103 —106	...	...
180,400*l*	Do. do. do. to bearer, Nos. 2,344 to 5,500	...	103 —106	103 —106	...	...
201,600*l*	Do. do. 4 p. c. Mort. Debs. Nos. 1 to 2016, red. 1909	100	99 —101	99 —101	...	...
45,000	Electric Construction, Limited, Nos. 101 to 45,100	10	5 — 6	5 — 6	...	...
19,900	*Electricity Supply Co. of Spain, Nos. 101 to 20,000	5	4½— 5	4½— 5	...	...
66,750	Elmore's French Patent Copper Depositing Co., Ltd, Nos. 1 to 66,750	2	1⅜— 1⅝	1⅜— 1⅝	1⅜	1 7/16
70,000	Elmore's Patent Copper Depositing, Limited., Nos. 1 to 70,000 ...	2	2¾— 3¼	2 — 2½	2	1⅞
67,385	Elmore's Wire Mfg., Ltd., Nos. 1 to 67,385, issued at 1 p.m., all pd.	2	1 — 1½	1 — 1½	...	...
20,000	Fowler-Waring Cables, Nos. 301 to 20,300 ... (£4 only paid)	5	2½— 3½	2½— 3½	...	...
180,227	Globe Telegraph and Trust, Limited	10	9⅛— 9⅜	9¼— 9½	9½	9¼
180,042	Do. do. 6 p. c. Preference	10	14⅛— 15⅛	14⅜— 15⅝	15	14 15/16
150,000	Great Northern Tel. Company of Copenhagen	10	17¾— 18¼	18 — 19	18¾	18½
230,000*l*	Do. do. 5 p. c. Debs. (issue of 1883) ...	100	105 —108	105 —108	...	...
9,334*l*	Greenwood and Batley, Ltd., Ordinary, Nos. 4667 to 14,000 ...	10	10 — 11	10 — 11	...	...
5,334*l*	Do. 7 p. c. Cumulative Preference, Nos. 2,667 to 8,000	10	11 — 12	11 — 12	...	...
41,600	India-Rubber, Gutta Percha and Telegraph Works, Limited ...	10	18½— 19½	18½— 19½	19⅜	19
200,000*l*	Do. do. 4½ p. c., Deb., 1896	100	102 —104	102 —104	...	...
17,000	Indo-European Telegraph, Limited	25	42 — 44	39 — 41	...	...
11,334	International Okonite, Ltd., Ordinary Nos. 22,667 to 34,000	10	7½— 8½	7½— 8½	...	...
11,334	Do. do. Preference Nos. 5,667 to 17,000 ...	10	9½— 9⅝	9¼— 9⅜	...	...
38,348	London Platino-Brazilian Telegraph, Limited	10	7 — 8	6½— 7½xd	...	...
100,000*l*	Do. do. do. 6 p. c. Debentures	100	106 —109	106 —109	...	...
43,900	*Metropolitan Electric Supply, Ltd., Nos. 6,101 to 50,000 (£9 paid)	10	9 — 9½	9 — 9½	9½	9¼
438,984	National Telephone, Limited, Nos. 1. to 438,984	5	4¼— 4⅜	4¼— 4⅜	4 7/16	4⅜
15,000	Do. 6 p. c. Cum., 1st Preference	10	13 — 13½	12¾— 13¼	...	...
15,000	Do. 6. p. c. Cum. 2nd Preference (£8 only paid)	10	10 — 10½	12 — 12½	...	...
350,000	Do. 4½ p.c. Deb. Stock Prov. Certs. fully paid ...	...	102 —104	102⅛—104	104	103
220,000	Oriental Telephone, Ltd., Nos. 80,001 to 300,000 (11s. only paid)	1	¼— ⅜xd	¼— ⅜	...	...
9,000	Reuter's Limited	8	8¾— 9¼	8 — 8½xd	...	...
209,750	South of England Telephone, Limited, Ordinary Nos. 1 to 2,000, 2,501 to 3,500, 93,251 to 300,000	1	⅛— ¼	⅛— ¼	...	...
20,000	Do. 6 p. c. Cum. Pref., Nos. 1 to 20,000 (£3½ only paid)	5	3 — 3½	3 — 3½	...	...
3,381	Submarine Cables Trust	Cert.	115 —120	113 —118	...	...
78,949	Swan United Electric Light, Limited ... ... (£3½ only paid)	5	4⅜— 5½	4½— 5 xd	...	...
37,350	Telegraph Construction and Maintenance, Limited	12	45 — 47	45 — 47	46½	...
150,000*l*	Do. do. do. 5 p. c. Bonds, red. 1894	100	102 —105	102 —105	...	...
58,000	United River Plate Telephone, Limited	5	2½— 3½	2½— 3½	...	...
146,128*l*	Do. do. 5 p. c. Debenture Stock ...	Stock	85 — 95	85 — 95	97	...
3,200*l*	Do. do. 7 p. c. Debs., Nos. 1 to 1,000 ...	100	... ...	... ...	...	...
15,609	West African Telegraph, Limited, Nos. 7,501 to 23,109	10	8 — 9	8 — 9	...	...
290,900*l*	Do. do. do. 5 p. c. Debentures	100	98 —101	97 —100	99	...
30,000	West Coast of America Telegraph, Limited	10	3 — 4	3½— 4½	4⅛	...
150,000*l*	Do. do. do. 8 p. c. Debs., repayable 1902 ...	100	95 — 100	97 — 102	...	...
64,174	Western and Brazilian Telegraph, Limited	15	12½— 13	11 — 11½xd	12 5/16	11¼
27,873	Do. do. do. 5 p. c. Cum. Preferred	7½	6¾— 7¼	6½— 7 xd	6¾	...
27,873	Do. do. do. 5 p. c. Deferred	7½	5½— 6	4¾— 5¼xd	5⅝	4⅞
200,000*l*	Do. do. do. 6 p. c. Debentures "A," 1910 ...	100	103 —106	103 —106	...	...
250,000*l*	Do. 6 p. c. Mort. Debs., series "B" of '80, red. Feb., 1910	100	103 —106	103 —106	...	...
88,321	West India and Panama Telegraph, Limited	10	3⅜— 3⅝	3¼— 3⅜	3 5/16	3¼
34,563	Do. do. do. 6 p. c. 1st Preference ...	10	11¾— 12¼	11¾— 12¼	...	...
4,669	Do. do. do. 6 p. c. 2nd Preference ...	10	11½— 12½	11½— 12½	...	...
$1,336,000	Western Union of U.S. Tel., 7 p. c. 1st Mortgage (Building) Bonds	$1,000	120 —125	117 —122	...	...
175,100*l*	Do. do. 6 p. c. Sterling Bonds	100	100—104	100 —104	...	..
42,853	*Westminster Electric Supply Corporation, Ord., Nos. 101 to 42,953	3	4⅞— 5⅛	4¾— 5¼	...	...

* Subject to Founders' Shares.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Blackpool Electric Tramway Company, Limited, £10 (£6½ paid), 7¼—7⅝.—City of London Electric Lighting (Pioneer), Shares of £50, £25 paid, 32—34.—Elmore's Austrian Copper Depositing, 15s., 25s.—Elmore's Priorities, 3⅞—4⅛.—House to House Company (£5 paid) 4½—5.—Liverpool Electric Supply, £3 paid, 2⅝—2¾.—London Electric Supply Corporation, Ordinary (£5 paid), 2⅛—2⅜.—Manchester, Edison and Swan Company, £9 (£1 paid) 2s 6d.—5s.—St. James's and Pall Mall Electric Light £5, 5⅞—6⅛.—St. James's and Pall Mall, 7 per cent. pref., ⅝ to ¾ prem.—Woodhouse and Rawson Ordinary of £5 (£2 10s. paid), 2—2¼.—Preference, fully paid 3¾—4⅛.—Debentures 90—95.—Woods Electric Car, £10 paid, ⅜—1.

BANK RATE OF DISCOUNT.—4 per cent. (7th May, 1891).

PROCEEDINGS OF SOCIETIES.

Institution of Electrical Engineers.*

ON SOME EFFECTS OF ALTERNATING CURRENT FLOW IN CIRCUITS HAVING CAPACITY AND SELF-INDUCTION.

By Dr. J. A. FLEMING, Member.

(*Continued from page* 589.)

12. The writer witnessed some experiments made in the Standardising Laboratory, by Major Cardew, in which the above measurements were carried out. A condenser of ·5 microfarad was joined across the poles of an alternator, a Thomson deci-ampère balance was put in the charging circuit, and a Thomson multicellular electrostatic voltmeter across the terminals of the condenser. The readings of the voltmeter, v_1, and of the ampère balance, I, were taken simultaneously, with the following results:—

Frequency of current, n.	Volts across condenser poles, v_1.	Charging Current in Ampères, I.	
		Observed.	Calculated.
103	360	·132	·116
103	396	·145	·128
103	493	·175	·160
103	583	·200	·189
90	481	·150	·136
90	598	·187	·170

For the frequency $n = 103$, $p = 2\pi n = 647$, and for $n = 90$, $p = 565$.

Hence, since the condenser capacity, C, = ·5 microfarad = 5×10^{-7} farads, we have as the values of C p for the respective speeds $3{,}235 \times 10^{-7}$ and $2{,}825 \times 10^{-7}$, and the values of the condenser current are calculated from the relation $I = C\,p\,v_1$. The calculated values of the currents are all lower than the observed, and in about the same ratio, viz., about 10 per cent; but the speeds of the alternator, and therefore the current frequencies, were not known with a degree of accuracy sufficient to enable it to be determined how far the agreement of observation with theory is complete.

13. The relations between the capacity and self-induction necessary to bring about an increase of pressure at the condenser terminals when an alternator charges a condenser are well displayed by the use of a clock diagram of electromotive forces. Such diagrams have been given by Mr. Kapp in some recent papers, and the particular one here given is practically the same as one given to me by Major Cardew, who has also examined this particular problem. The following mode of regarding it will be found to be an easy one. Construct a clock diagram of electromotive forces (see fig. 8) for the simple case of a

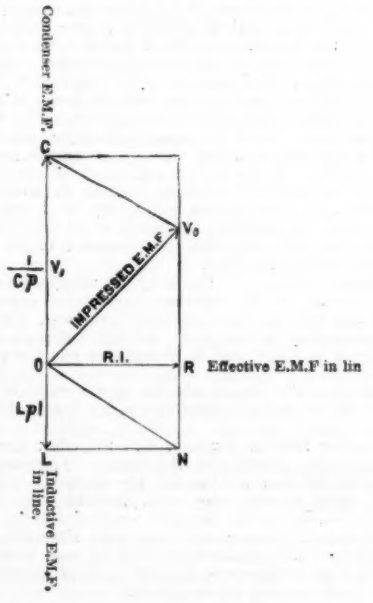


FIG. 8.

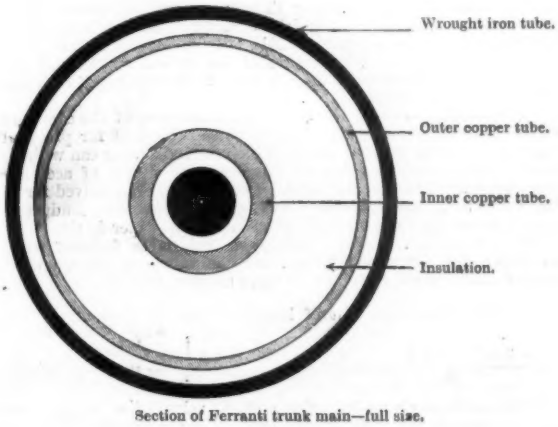
condenser charged through an inductive line by a constant harmonic impressed electromotive force. Lines drawn radially from a point, O, in fig. 8 represent the maximum values of various electromotive forces. Let O v_0 be the maximum value of the impressed E.M.F. at the dynamo terminals, and O C that at the condenser terminals; I the maximum current in the line. Take any line, O R, to represent the effective E.M.F. in the line, and therefore equal to the product R I, where I is the current charging the condenser, and R is the resistance of the line. From R draw R L at right angles to O R, and let R L be set off equal to L p I; L being the inductance of the line, and p being, as usual, 2π times the frequency of the current. Note that when a quantity varies harmonically the product of p and its maximum value gives us the maximum value of its time rate of change, or time differential, whilst the quotient of its maximum value by p gives us the maximum value of its time integral. Accordingly, O L, which is made equal to L p I, represents the counter electromotive force of self-induction, or back E.M.F., in the line as far as is due to its own inductance, and is in quadrature with R I as regards phase. Hence the resultant of these two is O N. Next, set off O C at right angles to O R, and in advance of it, and make O C equal to $\frac{I}{C\,p}$, that is, to the maximum value of the quotient of the time integral of the charging current by the capacity of the condenser. This gives us the counter electromotive force of the condenser, or the E.M.F. at the terminals of the condenser, v_1. We have then to take the resultant of this last and O N, which gives us O v_0, and this last resultant is the impressed electromotive force at the dynamo terminals.

It is necessary to bear in mind that the counter electromotive force, O C, at the terminals of the condenser is in quadrature with the current flowing into it, and in advance of it in phase. The diagram shows us at once that the pressure, v_0 = O v_0, at the terminals of the dynamo may be less than, equal to, or greater than the pressure, v_1 = O C, at the terminals of the condenser; and that this is determined by whether the length of the line, $O v_0 = \sqrt{O R^2 + v_0 R^2}$, is greater or less than O C. We see that $v_0 R = O C - O L = \frac{I}{C\,p} - L\,p\,I$, and hence that O v_0 is equal to the square root of $\left\{R^2 + \left(\frac{1}{C\,p} - L\,p\right)^2\right\} I^2$. Hence the maximum value of the charging current, I, is given by the value of

$$\frac{C\,p\,V_0}{\sqrt{R^2\,C^2\,p^2 + (1 - C\,L\,p^2)^2}}.$$

Also, we have the same quantity given by the relation $I = C\,p\,v_1$ hence the ratio of v_0 to v_1 is given by the value of the quantity $\sqrt{(1 - C\,L\,p^2)^2 + C^2\,R^2\,p^2}$, as we have already seen analytically. The clock-diagram has the advantage that it shows us at once the various lags, and gives explicitly to the eye a proof that a gradual increase in the value of the inductance, L, from zero upwards is accompanied by a progressive decrease in the value of the terminal pressure, v_0, at the dynamo, as compared with the terminal pressure, v_1, at the condenser.

14. In the next place, I wish to place before you an analysis of some experiments which have been made on great lengths of the Ferranti trunk mains between London and Deptford, and which illustrate these principles in a remarkable manner. We are all aware that these cables are concentric cables, and that they possess, accordingly, very measurable electrostatic capacity. The following are the data of the dimensions of these cables, kindly given to me by Mr. Ferranti. The inner conductor, or inner member, is a copper tube (see fig. 9) of which the inside diameter of cross section will be



Section of Ferranti trunk main—full size.

FIG. 9.

called D_1, and radius R_1, and the outside diameter D_2, and radius R_2. The outer conductor, or member, is a copper tube of which the inside diameter will be called D_3, and radius R_3, and its outside diameter D_4, and radius R_4. The insulation between the inner and outer members is compressed brown paper and black wax. The values of the diameters and radii of cross section of these tubes are as follows (see fig. 7):—

D_1 = $\frac{5}{16}$ths of an inch = ·5625 in.
D_2 = $\frac{13}{16}$ths " " = ·8125 "
D_3 = 1$\frac{37}{64}$nds " " = 1·8437 "
D_4 = 1$\frac{13}{16}$ths " " = 1·9375 "

* Paper read May 7th, 1891.

Hence we have—

$R_1 = \cdot281$ in. $\quad R_1^2 = \cdot0789$

$R_2 = \cdot406$ " $\quad R_2^2 = \cdot1648$

$R_3 = \cdot922$ " $\quad R_3^2 = \cdot8500$

$R_4 = \cdot969$ " $\quad R_4^2 = \cdot9389$

$R_2^2 - R_1^2 = \cdot0859$ " $\quad R_4^2 - R_3^2 = \cdot0889$

Area of cross section of inner member =

$$\pi (R_2^2 - R_1^2) = \cdot2689 \text{ sq. in.} = \tfrac{1}{4} \text{ sq. in., nearly.}$$

Area of cross section of outer member =

$$\pi (R_4^2 - R_3^2 = \cdot2793 \text{ sq. in.} = \tfrac{1}{4} \text{ sq. in., nearly.}$$

Also we have—

$$\frac{R_3}{R_2} = 2\cdot270, \qquad \frac{R_2}{R_1} = 1\cdot444, \qquad \frac{R_4}{R_3} = 1\cdot051,$$

$$\frac{R_1^2}{R_2^2 - R_1^2} = \cdot9185. \qquad \frac{R_4^2}{R_4^2 - R_3^2} = 10\cdot561,$$

$$\frac{2 R_1^4}{(R_2^2 - R_1^2)^2} = 1\cdot6872, \qquad \frac{2 R_4^4}{(R_4^2 - R_3^2)^2} = 223\cdot068,$$

$$\log_e \frac{R_3}{R_2} = \log_{10} 2\cdot27 \times 2\cdot3026 = 2\cdot3026 \times \cdot35603.$$

These quantities are required in the calculation of the inductance of the cable.

If the specific inductive capacity of the dielectric were a definitely known quality, it would be, of course, easy to calculate from the above figures the capacity of one mile run of the cable by the formula,

$$\text{Capacity in electrostatic units} = \frac{K l}{2 \log_e \frac{R_3}{R_2}},$$

K being the specific inductive capacity, and l the length; and to reduce this to farads by multiplication by $\frac{1}{9 \times 10^{11}}$.

In default of information to enable this to be done, the electrostatic capacity of one length was measured directly by comparison with a standard half a microfarad.

On December 5th, 1890, Mr. Ferranti placed at my disposal two lengths of the trunk mains running from Trafalgar Square to Blackfriars, for the purpose of measuring the capacity. The length of cable used was 2,399 yards, or 1·363 statute miles. The capacity of one of these lengths (No. 3 cable) was found in the usual way (taking the capacity between the inner and outer members) to be ·5 microfarad for the whole length, or at the rate of ·367 microfarad per statute mile. It follows from this that the specific inductive capacity of the material used is about 3·4 (air = 1). Using the other cable (No. 4), the copper resistance was found to be ·324 legal ohm, or ·328 B.A. units per statute mile, reckoning the resistance per mile run of the cable, and including, therefore, both the inner and outer conductor. The insulation resistance between the inner and outer member of the first cable was found to be at the rate of 720 megohms per mile. The instruments used in taking these measurements were a half-microfarad condenser by Dr. Muirhead, and a legal ohm Wheatstone bridge and megohm standard, kindly lent by Messrs. Elliott Bros. for the purpose. The temperature of the ground on that day was near the freezing point, and Nature saved us the trouble of reducing the values to zero centigrade.

The remaining element required is the inductance of the cable per mile. Fortunately, the form of cable which is the best for practical reasons, is almost the only case in which the inductance can with no great difficulty be calculated with any required degree of accuracy from the dimensions of the cable. Lord Rayleigh has solved for us the problem of the inductance of a pair of concentric conductors placed co-axially. His formula, as given in his paper in the *Philosophical Magazine* of May, 1886, page 385, is as follows, when translated into my nomenclature, and the values of the magnetic permeabilities of the materials all taken as equal to unity:—

$$L = \text{inductance per unit of length} = 2 \log \frac{R_3}{R_2} + \frac{2}{R_3^2 - R_2^2} - 3 R_1^2 + \frac{R_1^4}{R_2^2 - R_1^2} \log \frac{R_2}{R_1} + \frac{2}{R_4^2 - R_3^2} \left(\frac{R_3^2 - 3 R_4^2}{4} + \frac{R_4^4}{R_3^2 - R_3^2} \log \frac{R_4}{R_3} \right)$$

The logarithms are all Naperian, and the values of $R_1, R_2, R_3, \ldots, R_4$ may be taken in any units, as only their ratios are required.

The values of the chief functions of the radii of the tubes have been given above, and, making the substitutions, we have for the inductance of one centimetre run of the cable the following value:—

$$L = 2 \log 2\cdot27 + 1\cdot6872 \log 1\cdot444 + 223\cdot068 \log 1\cdot051 - (\cdot9185 + 10\cdot561).$$

Remembering that the logarithms here are Naperian, and that the logarithms to base 10 must be multiplied by 2·3026 to reduce them to the Naperian base, we have as a final result of the calculation,

$$L = 1\cdot7755 \text{ centimetres.}$$

Hence, since one statute mile = 160,931·5 centimetres, the inductance per statute mile of the Ferranti cable is 285,734 centimetres = ·0002857 of a henry, or 285·7 microhenries.

This result will be accurate to just the extent to which the diametrical measurements of the conductors are accurate.

Collecting our results, we have for one statute mile run of the Ferranti trunk main the following values, as deduced from measurements on the particular lengths employed:—

R = Copper resistance at 0° cent. of lead and return = ·324 legal ohm per mile.

K = Insulation resistance of length measured at rate of ... ... = 720 megohms per mile between inner and outer conductor.

C = Electrostatic capacity between inner and outer conductor ... ... = ·367 microfarad per mile.

L = Inductance ... ... = 285·7 microhenries per mile.

The formula given above for the inductance per unit of length can be applied to stranded concentric cables with a fair degree of approach to accuracy.

Suppose that we are sending periodic currents having a frequency of 67 through the Ferranti cables, then, if n = frequency = 67, $2\pi n = 421 = p$, and $4\pi^2 n^2 = p^2 = 177{,}241$.

Hence, since R = ·324 ohm, and L = ·000286 henry, we have $\sqrt{R^2 + p^2 L^2} = \cdot3455$ ohm for the impedance per mile, and we see that at this frequency the impedance exceeds the resistance by about 7 per cent. of the latter.

From the data thus given other functions of the capacity, C, inductance, L, resistance, R, and impedance, I, per mile can be built up, which will be required presently. These are—

$$P^2 = \frac{C p}{2} \left\{ \sqrt{R^2 + p^2 L^2} - p L \right\} = \cdot00001738;$$

$$Q^2 = \frac{C p}{2} \left\{ \sqrt{R^2 + p^2 L^2} + p L \right\} = \cdot00003597.$$

Hence, also,

$$P = \cdot004168, \; Q = \cdot005997;$$

$$P^2 + Q^2 = \cdot00005335, \; \frac{P^2 + Q^2}{I^2} = \frac{447}{10^6}$$

$$(2 P R + 2 Q L p) = \cdot004147;$$

$$(2 P L p^2 - 2 Q p R) = -1\cdot216.$$

All the quantities refer to one mile run of the cable.

(To be continued.)

A FEW CALCULATIONS ON ELECTRICAL SHOCKS FROM CONTACT WITH HIGH-PRESSURE CONDUCTORS.

By Major P. CARDEW, R.E., Member.

IN connection with the public supply of electrical energy in which very high pressures are used, it is important to investigate the amount of shock to which persons may be exposed by contact with one conductor under various conditions of insulation and electrostatic capacity of the conductors. Serious attention is now being directed to the effect upon the human organism of shocks with steady, intermittent, or alternating currents, and the necessity for exact electrical measurement in such investigations is fully recognised.*

The present opinion upon the subject may be stated to be, roughly, as follows:—The effect of an electric shock produced by the passage of a current through the body during an appreciable time is probably proportional to the square of the current, as regards injury by destruction or heating of tissue, with all kinds of currents; while alternating and intermittent currents produce, in addition, effects upon the nerves and nerve centres which may be directly injurious in themselves, and are generally indirectly so by producing temporary paralysis, and thus depriving the recipient of the power of terminating the period of contact.

The resistance opposed by the body to unidirectional and to alternating currents of the ordinary frequencies appears to be different, at any rate for low electrical pressures, that with the former being considerably the higher; but this difference diminishes as the pressure is increased, and is probably an effect of polarisation in the tissues.

This resistance is also largely affected by the extent of surface of the body through which the current enters, and the condition of the skin.

Without dealing further, however, with the effect produced, the following calculations merely give the current, or discharge through the body, under different conditions; the electrical impedance to the flow to earth through the body, including the resistances at the point of contact and in the earth connection, being taken as a constant resistance—r for continuous, and r' for alternating currents. The charging source is considered to be in all cases perfectly insulated, of negligible electrostatic capacity, and of ample power to maintain the pressure under all conditions.

The principle upon which the following calculations are based is, that every electrical machine must at any instant, or during any time, however extended, produce equal quantities of what used to be called "positive" and "negative" electricity.

This fact is as true of a dynamo as of a piece of sealing wax and its rubber; the emission from the source, whether it be a steady current or a small charge, is equal from the positive and negative pole. Thus, if one pole be connected to a conductor of large capacity, it will

* *Vide* the papers by Messrs. Stone, Newman Lawrence, and Harris.

necessarily be at a potential nearer to the earth than the other pole, if the latter be connected to a conductor of smaller capacity, and the whole system thoroughly insulated; and in every case this principle determines the potentials from earth of any electrified system, leaving out of question any extraneous charge imparted to it.

The first case to be considered is that of two perfectly insulated conductors, A and B, of considerable cross section, and capacities K and K′, kept charged to a steady difference of potential V. The mutual electrostatic induction is assumed to be negligible, and in general will be so, as the conductors are separated by some distance.

The potential of the earth will differ from that of A by an amount $\frac{K' V}{K + K'}$, and of B by an amount $\frac{K V}{K + K'}$, and there will be equal charges on the conductors.

If now a person making good earth with some part of his body touches conductor A with another part, the transmission through him will be not only the charge on A, but the equivalent of the opposite sign to the additional charge flowing to B to raise its potential to V. Thus the quantity that will pass through him will be

$$\frac{K K' V}{K + K'} + \left(K' V - \frac{K K' V}{K + K'}\right) = K' V.$$

The emission from the source being again equal in the two conductors, and amounting to

$$K' V - \frac{K K' V}{K + K'} = \frac{K'^2 V}{K + K'},$$

the maximum current through the body will be

$$\frac{K'}{K + K'} \times \frac{V}{r}.$$

Similarly, if contact be made with B, the quantity in the discharge will be K V, the emission from the source $\frac{K^2 V}{K + K'}$, and the maximum current

$$\frac{K}{K + K'} \times \frac{V}{r}.$$

Thus it appears that where the capacities of the charged conductors are unequal, contact with the conductor of least capacity will produce the greatest shock, the quantities passing through the body, and currents, being in the inverse proportion of the capacities in the two cases.

This case is perhaps not very practical, as electric supply mains, unless one was an aerial conductor and the other buried, would be, as a rule, equal in capacity. Also, there would be in any length of mains great probability of sufficient leakage to determine the potentials, irrespective of capacity, with continuous currents.

Secondly—Let the conductors A and B be concentric tubes, as in the Ferranti mains, B being outside and entirely enclosing A, except at the two ends, where the conductors are connected to the generator and receiver respectively, or to the generator at one end, and the other insulated, which is the simpler case to consider.

In this case there will be no inductive action between the conductors and the earth with the conditions postulated for the generating source, and in the absence of any extraneous charge, and the potential of B with respect to the earth will be zero.

For the quantities on A and B must be equal, and no free charge can be given to B by the source unless it is leaky. If the conductors are transmitting working currents, this condition will be modified by the slope of potential on B, which will then, if insulated, be at zero-potential at the centre of its length.

The same reasoning holds with alternating currents, but in this case the tendency to low potential on the outer conductor is stronger on account of the capacity current.

In fact, with such a length of cable as is used on the Deptford trunk mains—each main having, I am informed by Dr. Fleming, a capacity of about 15 microfarads between the outer conductor and the earth—it would be necessary to have such a considerable leak on the generator or receiver at or near the point of connection to the inner conductor, to raise the potential of the outer much above the earth, that, considering the pressure on the inner conductor, a breakdown must result, and this even if there were no metallic connection to earth on the outer conductor.

It is obvious, too, that no leakage between inner and outer could affect the potential of the latter, except to the extent due to the resulting current and the resistance of the conductor.

The writer pointed out at the time that the question of the use of an earth connection on these trunk mains was first discussed, that the outer conductor would even without this connection always be at a low potential so long as the circuit was in a workable condition; and he has recently been informed that this is found to be the case at Rome.

The earth connections in use have, however, important functions as safeguards in the event of a breakdown in a main transformer.

It is somewhat curious to note that the charge on the outer conductor of the Deptford trunk mains at any instant does not come from the terminal of the dynamo in connection with this conductor, but from that connected to the inner conductor, and passes through the transformer.

Thirdly—let the capacities of A and B be negligible, but their insulation be no longer perfect, the insulation resistance of A being R, and of B, R′.

Then with a steady P.D. the potential of A will be $\frac{R V}{R + R'}$, and of B, $\frac{R' V}{R + R'}$, on the principle of equal emission,

If contact be now made with A, its potential is at once reduced to

$$\frac{r R V}{r R + R' (R + r)},$$

and that of B increased to

$$\frac{R' (R + r) V}{r R + R' (R + r)};$$

the current through the body being

$$\frac{R V}{r R + R' (R + r)}.$$

If the conductors have appreciable capacity as well as leakage, there will result in every case a discharge through the body due to the rearrangement of potentials with respect to the earth, since the effect of the contact must be to lower the potential of the conductor touched.

Fourthly—The general case with leakage and capacity with alternating currents.

This requires working out. Let, as before, A and B be the two conductors between which an alternating pressure, maximum V, is maintained at a frequency n; and let them be considered to be separate conductors with negligible mutual electrostatic induction.

Let K be the capacity,
R insulation resistance } of A.
K′ capacity,
R′ insulation resistance } of B.
V_a maximum pressure of A from earth;
V_b maximum pressure of B from earth;
$p = 2 \pi n$.

The current at any instant flowing to each conductor will be compounded of the charging and leakage currents respectively, and the phase angle between the pressure and the current for each conductor will depend upon the capacity and insulation resistance, and will not be the same for the two conductors unless the product of the capacity and insulation resistance is the same for each.

But the current in each conductor must be identical in phase, and equal at any instant, on the principle of continuity.

Therefore in general there will be a difference in phase between V_a and V_b as shown in fig. 1.

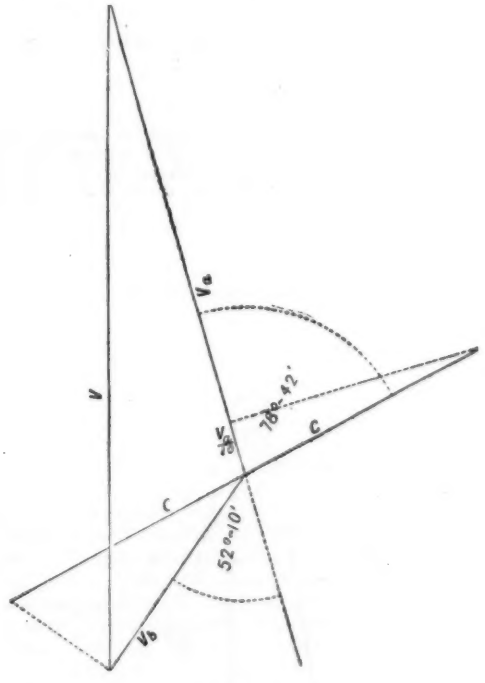


FIG. 1.

Let ϕ be the angle measuring this difference; and assuming the sine law of variation, we have at any instant the potential of A $= V_a \sin \alpha$, and of B $= V_b \sin (\alpha + \phi)$, where α is the phase angle; and as the quantity flowing to each conductor in the succeeding instant is the same,

$$K V_a d (\sin \alpha) + \frac{V_a}{R} \sin \alpha \, d t =$$

$$K' V_b d [\sin (\alpha + \phi)] + \frac{V_b}{R'} \sin (\alpha + \phi) d t,$$

or $p K V_a \cos \alpha + \frac{V_a}{R} \sin \alpha = p K' V_b \cos (\alpha + \phi) + \frac{V_b}{R'} \sin (\alpha + \phi)$.

Since this equation is true for all values of α, let $\alpha = 0$, then

$$p K V_a = p K' V_b \cos \phi + \frac{V_b}{R'} \sin \phi \qquad (1)$$

Again, let $\alpha = \frac{\pi}{2}$, then

$$\frac{v_a}{R} = \frac{v_b}{R'} \cos\phi - p K' v_b \sin\phi \qquad (2)$$

whence, $$\tan\phi = \frac{p(K R - K' R')}{1 + p^2 K K' R R'} \qquad (3)$$

The straight line joining the extemities of v_a and v_b represents v in phase and magnitude; whence,

$$v_a^2 + v_b^2 + 2 v_a v_b \cos\phi = v^2 \qquad (4)$$

From these equations the values of v_a and v_b can be deduced in terms of v; but as the resulting formulæ are somewhat cumbrous, it is simpler to proceed thus:—First, determine ϕ from equation (3); secondly, determine θ, the angle between v_a and c, the current, from the equation,

$$\tan\theta = \frac{p K v_a}{\frac{v_a}{R}} = p K R.$$

The directions of v_a, v_b, and c are thus determined:—Take c of any convenient length on each side of the origin, and from the ends of c drop perpendiculars on v_a and v_b: the distances between the origin and the feet of these perpendiculars are proportional to $\frac{v_b}{R'}$ and $\frac{v_a}{R}$ and may be taken as v_b and $\frac{R'}{R} v_a$. This determines the length of v_a and v. In the example shown in fig. 1, $v_b = \frac{v}{2 \cdot 9}$ or the current through the leak $= \frac{v}{2{,}900}$, maximum.

Fifthly.*—If the insulation of the two conductors be supposed perfect before contact is made with one of them, the equations are simplified.

Let R be the conductor touched, then in the equations R becomes infinity, and $R' = r'$;

whence, $$\tan\phi = \frac{1}{p K' r'},$$

and $$v_b = \frac{p K r' v}{\sqrt{1 + p^2 r'^2 (K + K')^2}}.$$

Thus the maximum current through the body is given by the equation,

$$c = \frac{p K v}{\sqrt{1 + p^2 r'^2 (K + K')^2}} \qquad (5)$$

or, if v be virtual volts, this will be the current in virtual amperes.

Here again it appears that the discharge through the body varies directly as the capacity, not of the conductor touched, but of the oppositely charged conductor, as has been shown to be the case with unvarying pressure.

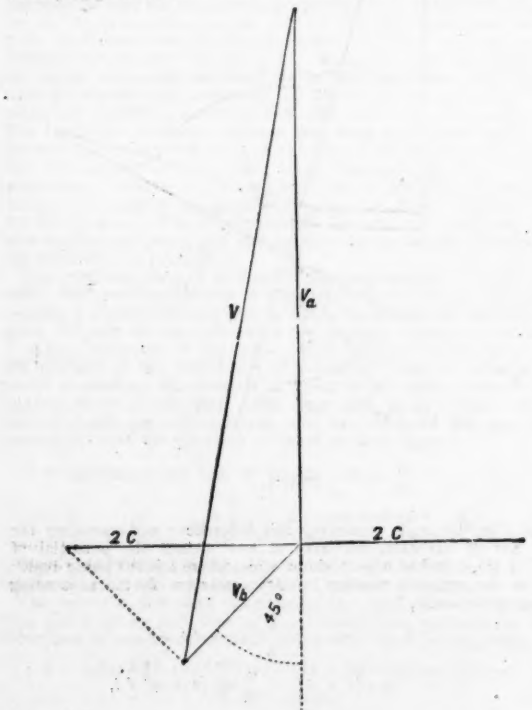


FIG. 2.

Fig. 2 shows the phases and relations of the quantities, v_a in this case being in quadrature with c.

* Cf. "On an unnoticed Danger in certain Apparatus for Distribution of Electricity," by J. Hopkinson, F.R.S., *Phil. Mag.*, Sept., 1885.

As a rule, with separate conductors the capacities of each with respect to the earth will be equal, in which case equation (5) is modified to the following:—

$$c = \frac{p K v}{\sqrt{1 + 4 p^2 r'^2 K^2}},$$

which may be written,

$$K = \frac{c}{p \sqrt{v^2 - 4 c^2 r'^2}}.$$

Supposing c, the current through the body, to have the maximum value which may be taken without injury—or, say, 20 milliampères—r' to be 2,000 ohms, v 2,000 volts, and p to have the value 500, we get from this K about ·02 microfarad only; which clearly shows the danger of touching bare conductors used for the supply of alternating currents at high pressure under any conditions.

NEW PATENTS—1891.

6,767. "Improved means for the production of ozone electrically." W. LUCAS and T. A. GARRETT. Dated April 20th.

6,782. "Improvements in dynamo-electric machines and electric motors." H. L. CALLENDAR. Dated April 20th.

6,831. "Improvements in dynamo-electric machines." A. L. PARCELLE. Dated April 21st. (*Complete.*)

6,847. "Improvements in printing telegraphs." S. R. LINVILLE and L. F. HETTMANSPERGER. Dated April 21st. (*Complete.*)

6,881. "An improved method of and apparatus for covering electric wires." J. E. WALCOTT. Dated April 21st. (*Complete.*)

6,890. "Improvements in and connected with electric locks." F. B. ASPINALL. Dated April 21st.

6906. "Improvements in arc electric lamps." G. WILKINSON. Dated April 21st.

6,963. "Improvements in means for staying telegraph, signal, and other posts, poles, or masts." C. E. SPAGNOLETTI. Dated April 22nd. (*Complete.*)

6,978. "Improvements in or relating to the automatic regulation of dynamo-electric machines." A. J. BOULT. (Communicated by W. Stone, Australia.) Dated April 22nd.

7,052. "Improved methods of obtaining electricity." W. BOGGETT. Dated April 23rd.

7,075. "Improvements in incandescent electric lampholders, ceiling roses, and other like fittings." F. H. ROYCE. Dated April 24th.

7,080. "Improvements in or connected with the manufacture of wall or other coverings, artificial leather, electrical insulators, boxes, and other articles from vegetable parchment. A. WILBAUX. Dated April 24th.

7,095. "Improvements in portable electric lamps." T. COAD. Dated April 24th.

7,126. "Improvements in electric lamp suspension fittings." H. JENSEN, J. JENSEN and WOODHOUSE & RAWSON UNITED, LTD. Dated April 25th.

7,127. "Improvements in apparatus for indicating the proper working of electrical bells, annunciators, and the like." H. JENSEN, J. JENSEN and WOODHOUSE & RAWSON UNITED, LTD. Dated April 25th.

7,167. "Improvements in electric arc lamps." T. HARDEN and F. E. PEARL. Dated April 25th.

7,168. "Improvements in and relating to voltaic cells." G. WESTER. Dated April 25th. (*Complete.*)

7,174. "Improvements in electric arc lamps." G. S. GRIMSTON and E. PERRETT. Dated April 25th.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1890.

42. "Improvements in the manufacture of cables suitable for the distribution of electric currents." W. S. SMITH. Dated January 1st. 6d. Small strings of hemp, cotton, or other yarn are saturated by prolonged boiling with solutions of wax, resin, paraffin, ozokerite, India-rubber or the like, or with an ammoniacal solution of copper to prevent moisture from creeping along by capillary attraction. These strings are then covered in an ordinary covering machine with gutta-percha or balata, or a blending of both, with which has been worked or mixed vulcanising agents such as are well known in the rubber trade. 3 claims.

58. "An improvement in or connected with incandescent electric lamps." H. GARDNER. (Communicated from abroad by W. Reid, of New York.) Dated January 2nd. 6d. Relates to the employment of a reflector fixed inside the bulb and between the filament of an incandescent lamp to diffuse and improve the light and to soften the glare. 2 claims.

615. "Improvements relating to electric switches, cut-outs, ceiling roses, and similar devices." R. B. EVERED and T. RUDLING.

Dated January 13th. 8d. The inventors construct the switches, wall-plugs, ceiling-roses and cut-outs in such a manner that they are enabled to dispense entirely with the screws heretofore employed for securing the terminals to the base or holder on which they are mounted. For this purpose they make the terminals by stamping them from metal and provide them with spikes which can be passed through the base or holder, and bent over at the back thereof in a groove which we form for the purpose, and which is afterwards filled with any suitable non-conducting material. 5 claims.

761. "Process of generating electricity by gas batteries." O. DAHL. Dated 17th June, 1889. (Under international convention.) 8d. Claims:—1. The process of generating electricity consisting in, first, raising the temperature of a body of fuel to incandescence by the aid of atmospheric air, utilising the gases evolved in this operation for fuel and other purposes; second, shutting off the air and admitting steam to the incandescent fuel when it has reached such a temperature that the admitted steam will be decomposed and hydrogen and carbonic acid formed; third, separating the carbonic acid from the hydrogen by causing suitable chemicals to absorb the carbonic acid, and conducting the hydrogen to one electrode of a gas battery or gas batteries; and fourth, producing oxygen or equivalent gas or liquid, and conducting it to the other electrode of the gas battery or gas batteries. 2. The process of generating electricity, consisting in, first, raising the temperature of a body of fuel incandescence by the aid of atmospheric air, and utilising the gases evolved in this operation for fuel or other purposes; second, shutting off the air and admitting steam to the incandescent fuel when it has reached such a temperature that the admitted steam will be decomposed, and hydrogen and carbonic acid formed; third, passing the gases through condensers and purifiers to take up impurities and condense the steam that might have escaped undecomposed; fourth, separating the carbonic acid from the hydrogen by causing suitable chemicals to absorb the carbonic acid and conducting the hydrogen to one electrode of a gas battery or gas batteries; and, fifth, producing oxygen or equivalent gas, mixture of gases or liquid, and conducting it to the other electrode of the gas battery or gas batteries.

1,280. "Improvements in switches used for electrical purposes." C. L. BAKER. Dated January 24th. 8d. The object of this invention is to produce a switch specially applicable for attachment to gas barrel or the like, where such may be used to supplement electric lighting or other purposes, and easily fitted to wood casing or the like, when required. 3 claims.

1,629. "Improvements in or relating to electric accumulators." A. J. BOULT. (A communication from G. G. DI GIOVANNI, of Italy.) Dated January 30th. 8d. The object of these improvements is to obtain at comparatively little cost lead plates so prepared and combined, that they may readily and quickly be fitted in, and taken out of, the desired position; also that, notwithstanding their small thickness, they may display considerable rigidity and great adhesiveness to their fittings; and lastly that the required intimate connection between the plates and their fittings, or in other words, an electric accumulator in working order, may rapidly be obtained. 6 claims.

8,393. "Improvements in switches for electrical circuits." B. M. DRAKE, J. M. GORHAM, and P. J. PRINGLE. Dated May 30th. 8d. In this invention the thumb piece changes the shape and position of a spring which re-acts upon the switch bar drawing it instantly home into the contact pieces and allowing the thumb piece to follow it; in breaking the circuit the thumb piece acts upon the spring and the spring instantly "draws off" the contact bar in the same manner as when closing the circuit. 2 claims.

11,440. "Electric railways." F. MANSFIELD. Dated July 22nd. 1s. 3d. Principally consists of a suitably insulated sub-surface main conductor having a series of movable connecting devices, or branch conductors, also suitably insulated, for establishing connection above the surface of the ground, the said connecting devices being automatically brought into operation as the car moves along its track, and arranged such a distance from one another that connection will always be established between the car and the main conductor. 44 claims.

15,456. "Improvements in or appertaining to welding metals electrically." W. P. THOMPSON. (A communication from abroad by C. L. Coffin, of America.) Dated September 30th. 6d. Claims:—1. The method described of welding metals electrically, which consists in bringing the parts to be welded in contact with an anvil and a conductor which is connected with one pole of a generator, connecting said articles with the other pole of said generator only, passing a heating current through the articles and conductor, and pressing the articles together and forming the weld while in contact with said conductor, substantially as set forth. 2. The apparatus for welding metals electrically, combined and arranged substantially as described.

16,522. "Improvements in the methods of and apparatus for working metals by electricity." G. D. BURTON. Dated October 17th. 11d. Consists in the method of making a forging by forming a blank of a determinate size for the forging to be produced; then softening said blank by passing an electric current therethrough; then cutting off said current and feeding the softened blank to the working dies; and then subjecting the blank to a forging or shaping operation. Consists further in a bar feeder; a bar cutter for cutting off a blank from the bar being worked; a metal working mechanism; and an electric heater disposed between the cutter and the metal working mechanism for heating the blank after it is cut from the bar and before it is subjected to the forging or other metal working mechanism. Consists further in the combination of forging dies; a feeder for feeding the metal to be worked to said dies; electrodes for heating said metal while out of contact with the dies; an electric circuit connected with said electrodes, and a variable resistance in said circuit between the source of electricity and said electrodes for regulating the current passed through said metal while out of contact with the dies. 11 claims.

16,571. "Improvements in secondary batteries." C. W. KENNEDY and H. GROSWITH. Dated October 18th. 8d. Consists, first, in the construction of the elements or electrodes separately considered, and, secondly, in the construction and combination of parts of the complete battery, resulting in the production of a storage battery wherein the following three important conditions will be found combined in an imminent degree, viz.: 1st, great electrical storage capacity; 2nd, lightness of weight in proportion to the size and capacity of the battery; and, third, durability, simplicity, and cheapness of construction. 7 claims.

16,518. "Improvements in arc electric lamps." J. E. A. GWYNNE. Dated October 17th. 8d. Constitutes an improvement upon the lamps described in and by the specifications of letters patent granted to C. D. Abel, No. 1,397, of A.D. 1880, and to W. R. Lake, No. 2,712, of A.D. 1882. 4 claims.

18,292. "Improvements in switches for electrical purposes." B. M. DRAKE and J. M. GORHAM. Dated November 13th. 6d. Relates to a new form of "spring" contact which enables any required amount of elasticity to be obtained. The spring contact is of U section, the ends being bent outwards to form the contact, and a screw is arranged between the two sides of the U to press them outwards for adjustment. 2 claims.

15,043. "Improvements in electric heating apparatus." W. R. LAKE. (Communicated from abroad by E. Abshagen, of America.) Dated September 23rd. 8d. Relates to improvements in electric heaters, in which one or a series of resistances are placed in the circuit of an electric current operated in conjunction with a surrounding non-conductive heat-containing material, and the object of the improvement is, first, to provide the resistance with a non-conductive material of a fluid and oily substance, such as sperm oil, cotton seed oil, lard oil, &c., or any other fatty oil of a non-volatile character, which fluid material, unlike others heretofore employed for this purpose, will always be in close contact with the resistance piece either when hot or cold, and not shrink away by expansion or contraction, as is the case in other apparatus for like purpose, where earthy or mineral non-conductors, like powdered clay, soapstone, plaster of Paris, &c., is employed. Second, to afford facilities for taking up and retaining the heat generated by the resistance piece in large quantities and at a high temperature. In order to remove the internal pressure to which the casing of the electrical heating apparatus is subjected by means of the expansion of the oil when heated, no precaution against internal pressure other than that caused by the expansion of the oil is needed to be guarded against. Third, to regulate the amount of heat required for each heater by shunting automatically the current which supplies the electric energy by means of an arrangement in the form of a governor set in operation by the heat developed in the oil and acting through the expansive force of this fluid against an expansion governor, which latter stands in connection with a shunt or rheostat of any approved form, whereby the amount of current supplied to the resistance piece will be automatically regulated, and the heat radiating from such electric heater will be maintained at an even temperature. 10 claims.

CORRESPONDENCE.

The Late Copper Syndicate.

I beg to be allowed to make some reply to your remarks in the REVIEW of the 1st instant under the heading, "The Late Copper Syndicate," from which I gather that you have not made yourself familiar with the facts and circumstances of the judicial proceedings in France, which have terminated in the Court of Cassation rejecting the appeal of M. Secrétan against the judgment of the Paris court condemning him to six months' imprisonment for the distribution of fictitious dividends, but that you are satisfied to take note of the result of the appeal, and to use it in your own way for disparaging everything and everyone connected with your *bête noir*—the Elmore process—with which you also appear to have only a superficial acquaintance.

As to the justice or injustice of M. Secrétan's condemnation I can confidently refer you to public opinion in France, which is tersely embodied in the letter of M. Léon Renault (one of the leading barristers in Paris, formerly prefet de police, and now senator, who has defended this lawsuit without pay, because he thought the prosecution to be thoroughly unjust), M. Secrétan's counsel, addressed to his client at the end of the case in the Paris Court last year, of which I enclose a copy. In regard to the recent decision of the Court of Cassation, this was purely on the question as to whether the proceedings of the lower court were legal, and was in no sense whatever a fresh hearing of the charge brought against M. Secrétan.

I ask what elements of justice can be found in proceedings which out of all the directors of the Société des Metaux are

levelled exclusively against M. Secrétan, for acts which must beyond all question have been the result of the resolution of the board of that Society, among whose members were to be found the following names: Edouard Hentsch, Albert Hentsch, André Girod, Puerari, Lecuyer, Emile Lavessiere, Josef Lavessiere, Labelonye, Champouillion, Joubert.

Nine persons out of ten in France would tell you that M. Secrétan alone of the members of the board was proceeded against for the distribution of so called "fictitious" dividends, as a scapegoat (as M. Renault calls him "victime expiatoire") for the rest, who have not been above allowing an innocent man to suffer vicariously.

I understand that M. Secrétan alone opposed the distribution of the said dividends, but was outvoted by his colleagues. M. Secrétan is also the only one of all the directors and of all the financiers who have been connected with the Copper Syndicate who has *given* away every centime of his fortune towards the liquidation of the Société des Metaux.

Referring to your quotation from the chairman's remarks at the general meeting of the French Elmore Company, held in January last, I have ascertained that the chairman and directors of that company emphatically confirm every word then said in appreciation of M. Secrétan's high integrity and ability.

You appear to fear that the sanguine anticipations of the chairman of the French company that M. Secrétan's energy would enable its works to be in operation in the month of July are doomed to be unrealised. You will therefore no doubt be pleased to learn that these anticipations are being fulfilled to the jot and tittle. M. Secrétan, some months ago, promised that the works at Dives would begin to turn out manufactured goods in July, and this will certainly be done.

At the present moment the works are three-fourths finished, as may be seen by anyone caring to visit Dives, and in their French laboratory, where their staff is being trained, the Company has already turned out absolutely perfect tubes of 4 and 5 metres in length, and of a diameter ranging from 30 mm. to 1·150 mm., and all difficulties connected with the working are to-day absolutely overcome.

The enforced absence of M. Secrétan is not likely to greatly inconvenience the Company, thanks to the energy with which he has pushed on the works and made his arrangements for the administration of the Company's affairs.

From a perusal of your many acrimonious references to the Elmore process, I and others are forced to conclude that you are not acting with the frank purpose of eliciting truth, but rather of harassing, to no purpose, an enterprise which fortunately, however, is of an intrinsic worth which places it above your power to prejudice it.

Henry Guarracino.

May 7th, 1891.

[COPY.]

Paris, 7, *Septembre*, 1890.

Mon cher Monsieur Secrétan,—J'ai revu et je vous envoie la sténographie de ma plaidoirie et de ma réplique devant la Cour. Je voudrais que leur publication pût profiter à votre cause devant la Cour de cassation saisie de votre pourvoi et, aussi, devant ce grand tribunal de l'opinion publique que les calomnies peuvent bien égarer un instant, mais auprès duquel la vérité finit toujours par avoir le dernier mot.

Je me suis tellement pénétré de vos souffrances imméritées pendant le cours des longs et cruels débats de votre procès, que je me suis senti blessé presque autant que vous par une condamnation contre laquelle ma conscience et ma raison protestent, malgré mon respect pour les decisions judiciaires.

Dans le monde de l'industrie, l'arrêt de la Cour de Paris a causé une surprise dont, hier encore, je rencontrais une preuve saisissante dans le langage qui m'était tenu par un grand fabricant de produits chimiques alsacien.

Il m'assurait que la conception qui a déterminé vos opérations sur le cuivre était juste, saine et eminemment française, et qu'elle indiquait, de votre part, une profondeur et une étendue de prévoyante clairvoyance exceptionnelle.

Dans un an me disait il les plus aveugles, les moins familiers avec les questions et les problèmes qui se lient à la production à la fabrication et au commerce du cuivre, seront obligés de reconnaitre que l'entreprise de Secrétan a été geniale et patriotique. Seulement, vous aviez suivant lui, commis une faute enorme en engageant avec la Compagnie du Rio Tinto des négociations pour la constitution de la "Metal Corporation" et "une telle aberration" lui semblait inconciliable avec le sage programme dont les premiers articles avaient été la campagne, a Londrès, contre la spéculation à la baisse sur le cuivre, et les traités directs avec les Compagnies minières.

J'ai dû lui expliquer que vous aviez été absolument étranger a cette déviation de votre conception originaire.

Pourquoi n'avez-vous pas été jugé par un jury d'industriels français? Ils vous aurait décerné une couronne; mais qui sait si demain ne réserve pas une éclatante revanche à votre droiture et à votre intelligence.

Le courage ne vous fera jamais defaut et vous aurez toujours, pour vous tendre la main, des amis devoués parmi lesquels je tiens à honneur que vous me comptiez.

Bien affectueusement à vous,

(s) LEON RENAULT.

Rus in Urbe.

Messrs. Verity would do well to cultivate a little caution in their "Trade Letters." A few days ago they stated that their goods were *not* made in Birmingham, although a month previous they said several times in the same column that their goods *were* made in Birmingham! A local paper, in "Table Talk," devotes no little space to clearing up the problem, Aston being as much a part of "Brum." as Westminster is of London. I append the "cutting" for your edification.

Elbow Grease.

A Wonderful Contrivance.

In your issue of April 3rd, under the heading of "Notes," you speak of a "Wonderful Contrivance," as appearing in this journal. Will you kindly oblige us by informing us the date such publication appeared in the *Review* and very much oblige,

Chas. W. Price,
Editor the Electrical Review (America).

New York, *April 25th.*

[We must apologise to our correspondent for having inadvertently printed Electrical *Review* for Electrical *Engineer*; the contrivance in question was described in the latter periodical, March 11th.—EDS. ELEC. REV.]

Electrification of Effluvia from Chemical or Voltaic Reactions.

With reference to the article under the above heading in your last number, perhaps you will kindly allow me to say that I do not for a moment admit the influences therein set forth. No one appreciates Mr. Brown's work more than I do. True, we disagree on the theory, and my reply to his arguments will appear in a paper to be read at an early date before the Physical Society. A matter of greater importance than the theory, which, however, I am not at all disposed to underrate, is the verification by Mr. Brown of the facts disclosed by my enquiry.

J. Enright.

May 12th, 1891.

Specific Resistance.

To use *per* to represent *of a* as well as *divided by* is certainly wrong. The term *microhms per cubic centimetre* in my article should have been written *resistance in microhms of a cubic centimetre.*

The use of *per* to represent *of a* is, however, habitual in England. Thus, we say, *insulation resistance per mile* when we should say, *insulation resistance of a mile*, or the *mileage insulation resistance.*

We might, of course, also say the *centimetre cubic resistance in microhms.* I think, however, that the terms *microhms centimetre* that has been introduced by recent French writers is quite as objectionable as *microhms per cubic centimetre.*

The term *microhms centimetre* does not on the face of it clearly define that the *resistance in microhms of a cubic centimetre* is meant. In fact, this definition is on a par with the French definition of the unit of inductance.

The ELECTRICAL REVIEW has pointed out the absurdity of naming the unit of inductance after a length (a quadrant) simply because in electro-magnetic units the ratio of two units of inductance in two systems of units is equal to the ratio of the two fundamental units of length. The secohm, on the other hand, clearly defines that the unit of inductance is equivalent to the introduction into a circuit of a force that produces an effect similar to an increase in the resistance of the circuit of one ohm during one second.

W. Moon.